United States
Department of
Agriculture

Soil
Conservation
Service

In cooperation with
Commonwealth of the
Northern Mariana Islands

Soil Survey of the Islands of Aguijan, Rota, Saipan, and Tinian, Commonwealth of the Northern Mariana Islands

How To Use This Soil Survey

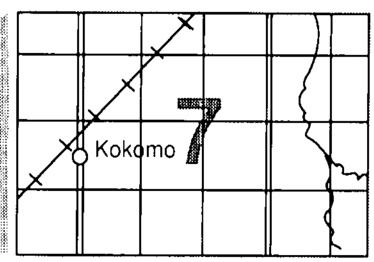
General Soil Map

The general soil map, which is the color map preceding the detailed soil maps, shows the survey area divided into groups of associated soils called general soil map units. This map is useful in planning the use and management of large areas.

To find information about your area of interest, locate that area on the map, identify the name of the map unit in the area on the color-coded map legend, then refer to the section **General Soil Map Units** for a general description of the soils in your area.

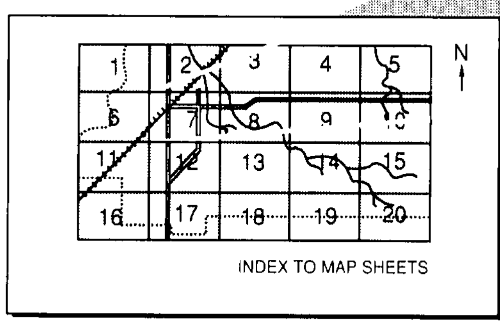
Detailed Soil Maps

The detailed soil maps follow the general soil map. These maps can be useful in planning the use and management of small areas.



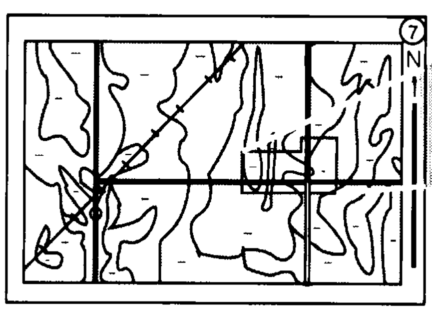
MAP SHEET

To find information about your area of interest, locate that area on the **Index to Map Sheets**, which precedes the soil maps. Note the number of the map sheet, and turn to that sheet.

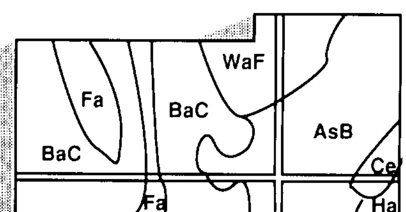


INDEX TO MAP SHEETS

Locate your area of interest on the map sheet. Note the map unit symbols that are in that area. Turn to the **Index to Map Units** (see Contents), which lists the map units by symbol and name and shows the page where each map unit is described.



MAP SHEET



AREA OF INTEREST

NOTE: Map unit symbols in a soil survey may consist only of numbers or letters, or they may be a combination of numbers and letters.

The **Summary of Tables** shows which table has data on a specific land use for each detailed soil map unit. See **Contents** for sections of this publication that may address your specific needs.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in 1985. Soil names and descriptions were approved in 1986. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1986. This survey was made cooperatively by the Soil Conservation Service and the Commonwealth of the Northern Mariana Islands. It is part of the technical assistance furnished to the Northern Marianas Soil and Water Conservation District.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

All programs and services of the Soil Conservation Service are offered on a nondiscriminatory basis, without regard to race, color, national origin, religion, sex, age, marital status, or handicap.

Cover: View of Mount Takpochao, the highest peak on Saipan. Soils are mainly those of the Chinen and Takpochao series. Limestone Rock outcrop is along the cliff lines.

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Issued July 1989

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Summary of Tables

Foreword

This soil survey contains information that can be used in land-planning programs in the Commonwealth of the Northern Mariana Islands. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.

Richard N. Duncan
State Conservationist
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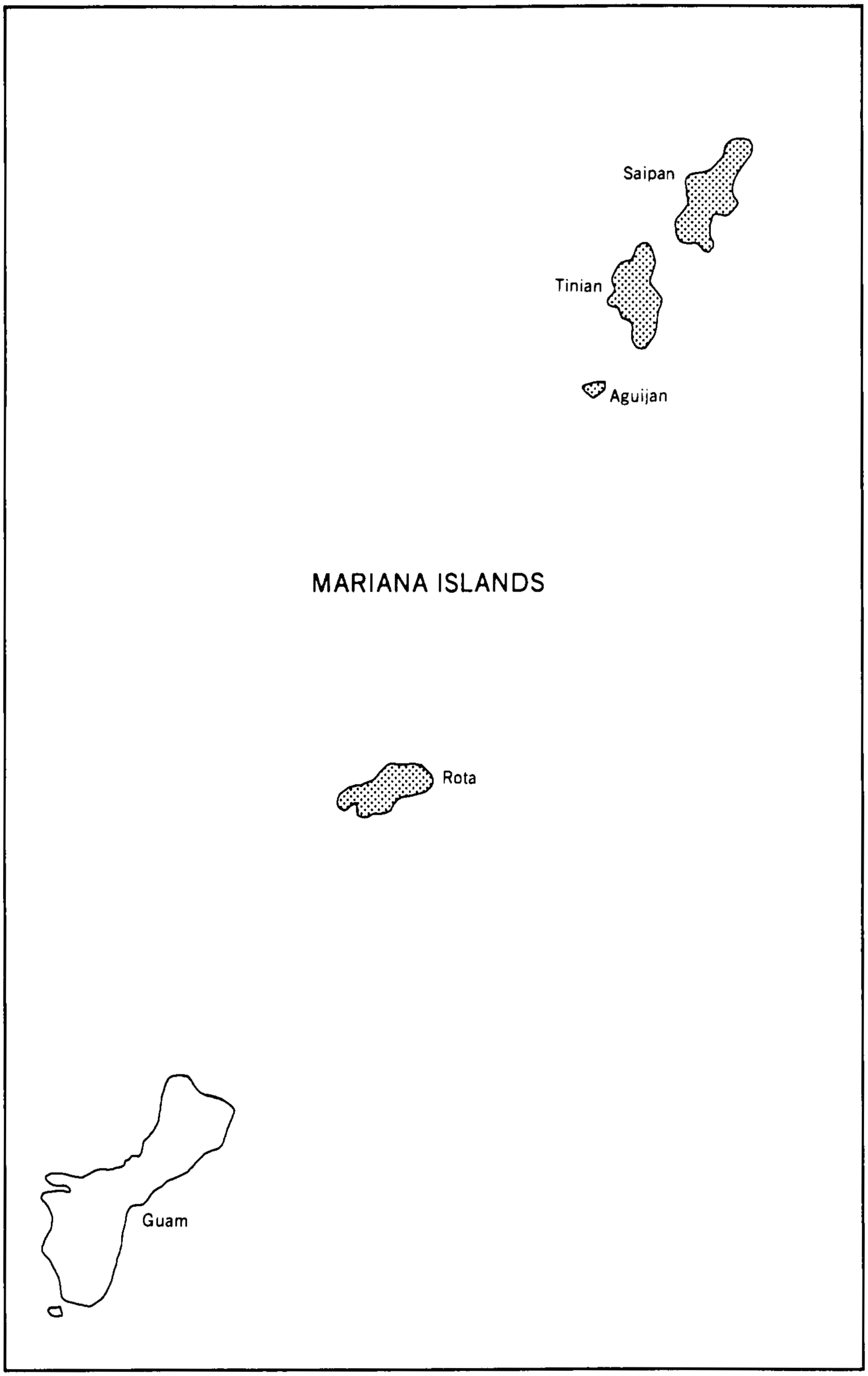

Location of the Commonwealth of the Northern Mariana Islands.

Soil Survey of the Islands of Aguijan, Rota, Saipan, and Tinian, Commonwealth of the Northern Mariana Islands

By Fred J. Young, Soil Conservation Service

Fieldwork by Dean W. Burkett, Terry L. Huff, and Fred J. Young,
Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service,
in cooperation with
Commonwealth of the Northern Mariana Islands

Commonwealth of the Northern Mariana Islands is an archipelago in the Western Pacific Ocean. It includes all of the Mariana Islands except Guam. Of the 14 islands in the Northern Marianas, only the four southernmost ones are included in this survey area. They are Saipan, Tinian, Aguijan, and Rota. Saipan, the largest and most populous of the islands, is about 200 kilometers north-northeast of Guam and 6,000 kilometers west-southwest of Hawaii. The total land area of the survey area is 31,480 hectares. Saipan is 12,065 hectares, Tinian is 10,176 hectares, Aguijan is 718 hectares, and Rota is 8,521 hectares.

Saipan is the seat of government and the center of population and commerce. The central spine of the island is mountainous and is capped by 466-meter-high Mount Takpochao. Most of the island is limestone, although the volcanic core is exposed in various places and makes up about 10 percent of the surface area. The limestone generally occurs as level or tilted plateaus interspersed with steep escarpments. Volcanic areas have complex slopes and generally are dissected by drainageways. Many volcanic areas are steep and eroded. An extensive swamp is in the southwestern part of the island, which contains the largest lake in the Northern Marianas. A large lagoon lies off the western coast, and most urban development is on the coastal plain bordering this lagoon.

Tinian is separated from Saipan by a strait 5 kilometers wide. The island is basically a series of five limestone plateaus that are at various elevations and are separated by steeply sloping areas and escarpments. Plateau surfaces generally are level to undulating. The highest point, on the southernmost plateau, is 187 meters. The volcanic core of the island is exposed in two places, although only the northern exposure is of significant size. There are no surface drainageways on the island. There is one small lake at the north end. The single village of San Jose is located on a southwestern exposure beside an excellent deep-water harbor.

Aguijan is popularly called Goat Island because of the feral goat population there. It is an uninhabited island 8 kilometers southwest of Tinian. Aguijan is composed of a series of three concentric limestone plateaus that are separated by nearly vertical escarpments. There are no harbors, and the continuous coastal escarpments make access difficult. Aguijan is officially designated as a wildlife reserve, and it is uninhabited by law.

Rota is also primarily an island of concentric limestone plateaus separated by escarpments. The plateau surfaces are level or gently to strongly tilted. The volcanic core emerges in several areas, two of which are extensive. One is Mount Manira, which at 496 meters is the highest point in the survey area. The other is the steep, dissected Talakhaya, where all of the surface drainageways are located. An isthmus connects the main landmass to Mount Taipingot (fig. 1). The village of Songsong is centered on the isthmus, and the recently established village of Sinapalu is near the airport.

The soils of Saipan originally were described and

Figure 1.—View of Mount Talpingot on Rota. Soils are mainly those of the Luta series on plateaus and of the Takpochao series on the steeper slopes. Limestone rock outcrop is along the cliff faces.

mapped by McCracken *(8)*, and those of Tinian were mapped by Stensland *(4)*. Information in these older reports was used extensively during fieldwork for this survey. Soil names were retained whenever possible, although series concepts have been refined. The only previously existing information on the soils of Rota was obtained by Rogers *(10)*. No information on the soils of Aguijan was available. Soils investigations in the Northern Marianas were conducted by the Japanese prior to 1940. The present survey updates all previous surveys and provides additional information and large maps that show the soils in greater detail.

General Nature of the Survey Area

This section briefly discusses the history and development, land use, and climate in the survey area.

History and Development

The Mariana Islands were discovered in 1521 by Ferdinand Magellan and were claimed for Spain in 1565 by de Legaspi. During the 100 years that followed, Spain paid little attention to the islands. The establishment of a Jesuit mission on Guam in 1668 led to profound changes in the lives of the Chamorros of the Marianas. Resistance by the Chamorros to the

activities of the priests led to open rebellion and warfare. Those Chamorros not killed in the wars were consolidated into villages on Guam. By 1698 all surviving Chamorros in the Northern Marianas, except for a few who remained hidden on Rota, had been transported to Guam by the Spaniards. The population further declined; a 1756 census shows that the total Chamorro population was 1,654. This population stabilized and increased as Chamorro women intermarried with Filipinos and Spaniards from Europe.

The first people to return to the depopulated Northern Marianas were Carolinians from outer islands of the Truk district. Driven from their home islands by a devastating typhoon, they settled on Saipan in 1815. Others followed, including about 1,000 in 1865 and 250 in 1869, who settled in Saipan, Pagan, and Tinian. Chamorros began migrating back to the Northern Marianas at about the same time, and the first Chamorro settlement of this period was established on Saipan in 1818. To this day the Chamorro and Carolinian peoples in the Northern Marianas, although politically integrated and harmonious, remain racially and culturally distinct from one another.

In 1898 Guam became a United States possession as a result of the Spanish-American War, and a year later Spain sold the Mariana and Caroline Islands to the Germans. Apart from a few Capuchin priests and government administrators, no Germans lived in the Marianas at that time. The German interest in the Islands was primarily economic. To this end, coconut plantations were established for copra production using local labor.

The German period came to an abrupt end in 1914, when the Marianas were seized by a Japanese naval squadron during the early days of World War I. In 1920 the League of Nations placed the islands under Japanese mandate. Unlike the Germans, the Japanese actively colonized the Marianas; by 1937 there were 42,000 Japanese on the islands. Sugarcane was grown extensively by the Japanese. In 1938, about 58 percent of Tinian, 32 percent of Saipan, and 29 percent of Rota were in cane, as well as extensive areas on Aguijan. Rail systems were used to transport cane to mills on Saipan, Tinian, and Rota. On Aguijan, cane was loaded onto ships by crane for transport to the Tinian mill.

The islands were heavily fortified prior to and during World War II, and Aguijan was abandoned during this time. In 1944 American forces took Saipan and Tinian after prolonged and bloody fighting. Rota was neutralized by air strikes and bypassed. The United States military administered the Northern Marianas until 1947, when the United States and the United Nations reached a trusteeship agreement for the Trust Territory of the Pacific Islands.

From the start of the trusteeship agreement in 1947, the people of the Marianas had petitioned for close political ties with the United States. In 1972 the Marianas' delegation to political status negotiations requested separate negotiations from the other Trust Territory island groups. This resulted in the signing of a covenant between the United States and the Northern Mariana Islands in 1975, which provided for the eventual establishment of the Commonwealth of the Northern Mariana Islands. A plebiscite in the Northern Marianas approved the covenant, which was enacted by the United States Congress on March 24, 1976. The people of the Commonwealth of the Northern Mariana Islands drafted a constitution, which was adopted by plebiscite and became effective on January 9, 1978. A constitutional convention in 1985 proposed modification of some provisions of the constitution adopted in 1978.

Along with commonwealth status has come economic growth, particularly for Saipan. The major contribution has been from the rapid expansion of tourism, which in 1982 accounted for 35 percent of the gross island product. Tourism has increased to more than 100,000 visitors annually, almost entirely from Japan. The Commonwealth of the Northern Mariana Islands government is the largest employer, followed by the tourist industry and agriculture. There are an estimated 3,000 Filipino and 300 Korean contract workers on the islands.

The population of the Northern Marianas was 16,780 in 1980. Of this total, 14,653 resided on Saipan, 1,261 on Rota, and 866 on Tinian. Aguijan is uninhabited.

Land Use

Land use in the Northern Marianas has gone through extreme changes in the past 50 years. Changes continue to take place, and extreme changes are possible in the future for Tinian.

Sugarcane production was a major land use during the Japanese occupation. World War II ended this land use, and most of the old cane fields are now in secondary forest or rangeland plants.

The Japanese military used large hectarages for airstrips, barracks, and fortifications; the U.S. military built even more airstrips and barracks. The entire northern plateau of Tinian was used for airfields, and virtually all of the broad limestone plateaus on Saipan were heavily built upon. Much of this land has been permanently altered by layers of concrete or gravel fill or by excavations for bunkers. Most areas are now

abandoned and, as have the canefields, have reverted to secondary forest.

About 70 percent of the survey area is in forest, either native forest or secondary *(9)*. This forest land is used mainly as watershed and wildlife habitat and for some subsistence uses. About 20 percent of the hectarage is grazing land, most of which is on Tinian. The balance is in urban and built-up areas, coastal shrublands, Susupe swamp, and other areas. Cropland constitutes a relatively small proportion of the total land use. More information on specific land uses is given in the appropriate sections of this survey.

About 20 percent of the land on the four islands of this survey area is privately owned. Rota is about 13 percent privately owned, Tinian 10 percent, and Saipan 33 percent. There is no privately owned land on Aguijan. The title to public lands is vested in the Marianas Public Land Corporation, which has responsibility for the management and disposition of all public lands.

The fastest growing land use on the islands is probably urban and recreational development on Saipan. This is a result of the burgeoning tourist industry. Tinian has recently undergone a profound change in land ownership patterns. The Marianas Public Land Corporation essentially bought all of the private lands on northern Tinian, and it leases 7,200 hectares, or 70 percent of Tinian, to the United States Military. Most of this land is not presently used by the military and is leased back to farmers and ranchers.

Climate

Climatic information is mainly from Van der Brug *(17)*; wind data were provided by the National Oceanographic and Atmospheric Administration.

The climate of the Northern Marianas is uniformly warm and humid throughout the year. Afternoon temperatures are normally about 30 degrees C, and nighttime temperatures are around 20 degrees. Relative humidity usually is about 70 percent in the afternoon and 90 percent at night.

There are two main seasons in the Northern Marianas, and these are defined by the amount of rainfall received. The dry season normally lasts from December to June, and the wet season from July to November. About two-thirds of the rain falls between July and November. Mean annual rainfall is about 200 centimeters, although areas at higher elevations, such as the Sabana on Rota, probably receive almost 250 centimeters (fig. 2).

Average monthly rainfall on Saipan is shown at the end of this paragraph. These values are the means from all German, Japanese, and American stations on Saipan. There are no published records for Tinian and Rota, but the climate there is not significantly different from that on Saipan, with the possible exception of the Sabana on Rota. Average monthly rainfall in centimeters on Saipan is—

January	10
February	8
March	8
April	8
May	9
June	13
July	24
August	32
September	34
October	27
November	19
December	12

The dominant winds in the Northern Marianas are the trade winds, which blow from the east or northeast. The trade winds are strongest and most constant during the dry season, when windspeeds of 25 to 40 kilometers per hour are common. During the rainy season there is often a breakdown of the trade winds, and on some days the weather may be dominated by westerly moving storm systems that bring heavy showers or steady, and sometimes torrential, rains.

The Northern Marianas lie in the path of typhoons spawned in the Western Pacific, which move west or northwest toward the Philippines or Japan. These typhoons not only bring heavy rainfall, but they also bring violent winds that may cause a surge of water onto low-lying coastal areas. Typhoons most frequently occur during the latter half of the year, but they have been recorded during every month of the year.

How This Survey Was Made

This survey was made to provide information about the soils and miscellaneous areas in the survey area. The information includes a description of the soils and miscellaneous areas and their location and a discussion of their suitability, limitations, and management for specified uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface

Figure 2.—Cloud buildup over the Sabana on Rota. The Luta soils on the Sabana are slightly cooler and wetter than the Luta soils on lower plateaus.

down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biologic activity.

A tile spade and a hand-operated bucket auger were the basic tools used in field mapping. Depth of observation with these tools did not exceed 2 meters, although slumps and road cuts allowed some deeper observations to be made. Soil pits were dug by hand to describe representative soil profiles.

Slope groupings on Rota and Aguijan were made using topographic maps and were verified in the field. Transects were conducted on the southern half of the island of Aguijan.

The soils and miscellaneous areas in the survey area are in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind or segment of the landscape. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept or model of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Individual soils on the landscape commonly merge gradually onto one another as their characteristics gradually change. To construct an accurate map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted color, texture, size, and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While the soil survey was in progress, samples of some of the soils in the area were collected for laboratory analyses and for engineering tests. Soil scientists interpreted the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils were field tested through observation of the soils in different uses and under different levels of management. Some interpretations were modified to fit local conditions, and some new interpretations were developed to meet local needs. Data were assembled from other sources, such as research information, production records, and field experience of specialists.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can state with a fairly high degree of probability that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

General Soil Map Units

The general soil map at the back of this publication shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit on the general soil map is a unique natural landscape. Typically, a map unit consists of one or more major soils or miscellaneous areas and some minor soils or miscellaneous areas. It is named for the major soils or miscellaneous areas. The soils or miscellaneous areas making up one unit can occur in other units but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils or miscellaneous areas can be identified on the map. Likewise, areas that are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The soils in any one map unit differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The general map units in this survey have been grouped into general kinds of landscape for broad interpretive purposes. Each of the broad groups and the map units in each group are described in the following pages.

Map Unit Descriptions

Soils on Lowlands

This group consists of three map units. It makes up about 2 percent of Saipan, 3 percent of Tinian, and 6 percent of Rota.

1. Mesei Variant

Moderately deep, very poorly drained, level soils; in depressional areas

This map unit is in depressional areas on Saipan and Tinian. More than 90 percent of the unit is level, and the rest is gently sloping. The vegetation is mainly solid stands of the water-tolerant reed called kariso. Some areas support other water-tolerant grasses, such as paragrass, and water-tolerant trees. A few small areas are urbanized or farmed.

This unit makes up about 1 percent of Saipan and less than 1 percent of Tinian. It is about 85 percent Mesei Variant soils and about 10 percent Inarajan soils and other components of minor extent, including areas of open water such as Hagoi Susupe on Saipan; small areas of Laolao, Chinen, and Shioya soils along unit boundaries; and a few small urbanized areas such as San Roque Village on Saipan.

Mesei Variant soils are moderately deep and very poorly drained. They formed in marine deposits, alluvium, and organic material. These soils are black muck 20 centimeters deep over very dark gray gravelly mucky clay loam and gray very gravelly sandy loam that extends to a depth of more than 100 centimeters. There is a permanent high water table that fluctuates between depths of 20 centimeters below the surface and 100 centimeters above the surface.

Inarajan soils are near the villages of San Roque and Tanapag on Saipan. These soils are very deep and somewhat poorly drained. They formed in alluvium and are clayey throughout. There is a seasonal high water table that recedes in the dry season.

This unit is used as watershed and wildlife habitat. A few areas of Inarajan soils are used as homesites and for subsistence farming.

Most areas of this unit are not suited to farming, grazing, or urbanization. The permanently high water table, a hazard of flooding, and low soil strength are severe limitations. In areas of Inarajan soils, farming and grazing are feasible during the rainy season.

This unit is well suited to wetland wildlife habitat, and it includes most of the wetlands in the Northern Marianas. Open water and plant cover are important habitat components for species such as the endangered Pulantat (Marianas gallinule).

2. Shioya

Very deep, excessively drained, level to nearly level soils; on coastal strands

This map unit is on coastal strands on Saipan and Tinian. Slopes are long and plane and range from 0 to 3 percent. The vegetation in areas not heavily urbanized is mainly forest.

This unit makes up about 1 percent of Saipan and 2 percent of Tinian. It is 85 percent Shioya soils. On Saipan, nearly 15 percent of the unit is Urban land. Of minor extent on Saipan are small areas of Chinen, Kagman, Mesei Variant, and Saipan soils. On Tinian, small areas of Urban land are included as well as small areas of Chinen and Takpochao soils.

Shioya soils formed in water-deposited limestone sand. Typically, the surface layer is very dark gray loamy sand over a substratum of very pale brown sand. Cemented sand is at a depth of 100 centimeters.

This unit is used for urbanization, subsistence farming, recreational development, wildlife habitat, and watershed. It can be used for commercial farming and grazing.

This unit is poorly suited to most commercial vegetable crops. The main limitations are the droughtiness and high salt content of the soils. The unit is well suited to subsistence tree crops such as coconut and breadfruit.

Grazing is limited by droughtiness, which restricts forage growth.

This unit is moderately suited to homesite and urban development. Most of the urbanized areas on Saipan are in this unit. There is a hazard of wave damage to structures during typhoons. Shioya soils will not properly filter effluent from septic tank absorption fields.

This unit is moderately suited to recreational development. Most of the beaches on Saipan are on or adjacent to this unit. Growth of turfgrass is limited by droughtiness and high salt content of the soils.

3. Takpochao Variant-Shioya

Very shallow and very deep, excessively drained, level to gently sloping soils; on coastal strands and coastal plateaus

This map unit is in Songsong Village and along the northern coast of Rota. Slopes generally are long and plane, but they are broken in places by narrow benches and short, steep escarpments. Slope is 0 to 10 percent. The vegetation is mainly forest.

This unit makes up about 6 percent of Rota. It is about 60 percent Takpochao Variant soils and 35 percent Shioya soils. Of minor extent are small areas of Urban land, Rock outcrop, and Luta soils.

Takpochao Variant soils are very shallow and excessively drained. They formed in water-deposited limestone sand and residuum. Typically, these soils are black and very dark gray very gravelly sandy loam over hard limestone at a depth of 10 to 50 centimeters.

Shioya soils are very deep and excessively drained. They formed in water-deposited limestone sand. Typically, the surface layer is very dark gray loamy sand over a substratum of very pale brown sand. Cemented sand is at a depth of 160 centimeters.

This unit is used for subsistence farming, wildlife habitat, watershed, urbanization, and recreational development. It can be used for grazing.

Takpochao Variant soils are too shallow and droughty for commercial or subsistence crops. The Shioya soils are poorly suited to most commercial vegetable crops. The main limitations are droughtiness and high salt content. The Shioya soils are well suited to subsistence tree crops such as coconut and breadfruit.

The main limitation of the unit for urban uses is the very shallow depth to limestone in the Takpochao Variant soils. The very deep Shioya soils are better suited to urbanization than are the Takpochao Variant soils. There is a hazard of wave damage to structures during typhoons. The soils in this unit will not properly filter effluent from septic tank absorption fields.

The main limitation of the unit for recreational development is the high content of gravel in the Takpochao Variant soils. Most of the coastal recreational facilities on Rota are in this unit.

Soils on Limestone Plateaus

This group consists of seven map units. It makes up about 36 percent of Saipan, 92 percent of Tinian, 69 percent of Rota, and 70 percent of Aguijan.

4. Banaderu-Rock Outcrop

Shallow, well drained, nearly level to moderately steep soils, and Rock outcrop; on limestone plateaus

This map unit is on the higher lying limestone plateaus on Saipan and Tinian. The Banaderu soils are in the broad central plateau areas. The Rock outcrop is on slope breaks and on plateau margins near escarpment edges. Slopes range from 0 to 30 percent. Areas of this unit on Saipan generally are more sloping than areas on Tinian. On Saipan, about 55 percent of mapped areas have slopes of 5 to 15 percent; on Tinian, about 80 percent of mapped areas have slopes of less than 5 percent. Slopes generally are long and concave. The vegetation is mainly forest. A large area on Tinian is farmed.

This unit makes up about 1 percent of Saipan and 2

percent of Tinian. On Saipan, it is about 75 percent Banaderu soils and 20 percent Rock outcrop. On Tinian, it is more than 90 percent Banaderu soils and less than 5 percent Rock outcrop. Of minor extent, on both islands, are small areas of Saipan soils and some areas of Takpochao soils along escarpments.

Banaderu soils formed in sediment over porous limestone. Typically, these soils have a thin, black mucky loam surface layer over a dusky red and dark red clay subsoil. Limestone is at a depth of 25 to 50 centimeters.

Rock outcrop consists of white, porous limestone derived from coral reef formations. The surface is jagged and irregular.

This unit is used for commercial and subsistence farming, grazing, watershed, and wildlife habitat. It can be used for urbanization and recreational development.

Nearly level areas of this unit are moderately suited to commercial or subsistence farming. These areas, such as those on Pina on Tinian, are limited by shallow soil depth. Other areas, mostly on Saipan, are limited by slope and Rock outcrop.

Most areas of this unit are well suited to grazing. Rock outcrop and slope limit rangeland management practices in some areas.

Nearly level areas are moderately suited to urbanization. The underlying limestone will interfere with excavation. Rock outcrop and slope are severe limitations in some areas.

The main limitations for recreational development are shallow soil depth and, in some areas, slope and Rock outcrop. The broad plateau areas are suited to ball fields, golf courses, and related facilities, whereas the steeper, rocky plateau margins provide good vantage points for trails and scenic overlooks.

The high plateaus of this unit are important watershed areas. The infiltration of rainwater into the porous limestone recharges the ground water supplies. The forested, isolated areas on Saipan provide important wildlife habitat.

5. Chinen-Takpochao

Very shallow and shallow, well drained, nearly level to strongly sloping soils; on limestone plateaus and side slopes

This map unit is on limestone plateaus on Saipan, Tinian, and Aguijan. Takpochao soils generally are in the strongly sloping areas and are on exposed coastal benches. About half of this unit has slopes of less than 5 percent. Slopes are long and plane. Vegetation is mainly forest. Some areas are in grasses and forbs or are farmed.

This unit makes up about 21 percent of Saipan, about 14 percent of Tinian, and about 70 percent of Aguijan. It is about 75 percent Chinen soils and about 20 percent Takpochao soils. Of minor extent in this unit are small areas of Chacha, Kagman, and Saipan soils on Saipan and some areas of Saipan soils on Tinian and Aguijan. Rock outcrop is associated with the Takpochao soils.

Chinen soils are shallow and well drained. These soils formed in sediment over porous limestone. Typically, they have a very dark grayish brown clay loam surface layer about 6 centimeters thick over a dark brown clay and yellowish red clay loam subsoil. Limestone is at a depth of 25 to 50 centimeters.

Takpochao soils are very shallow and well drained. These soils formed in sediment over porous limestone. Typically, they are black very cobbly loam and very dark grayish brown and dark yellowish brown very cobbly clay over limestone. Depth to limestone is 10 to 40 centimeters.

This unit is used for subsistence and commercial farming, grazing, urbanization, recreational development, watershed, and wildlife habitat.

Chinen soils are moderately suited to commercial and subsistence farming. They are limited by shallow soil depth and droughtiness. Takpochao soils are too shallow and cobbly to farm.

This unit is well suited to grazing. The main limitation is droughtiness. Rock outcrop in areas of Takpochao soils interfere with use of rangeland management practices.

Chinen soils are moderately suited to homesite and urban development. The shallow depth to bedrock interferes with excavation. Takpochao soils are severely limited by the areas of Rock outcrop.

The limitations for recreational development include droughtiness, slope in some areas, and Rock outcrop in areas of Takpochao soils. Broad, nearly level areas of Chinen soils in this unit are moderately suited to playgrounds, ball fields, and other recreational facilities.

This unit is underlain by porous limestone. The infiltration of rainwater into this limestone recharges the ground water supplies. Forested areas provide habitat for wildlife.

6. Chinen-Urban Land

Shallow, well drained, nearly level soils, and Urban land; on limestone plateaus

This unit is on limestone plateaus on Saipan, Tinian, and Aguijan. Many areas of this unit have been bulldozed and disturbed. Piles of rubble and debris are common. More than 90 percent of the soils in this unit have been modified or strongly altered by human activity. About 85 percent of this unit has slopes of less than 5 percent. Slopes are long and plane. The vegetation on the Chinen soils is mainly forest. Some areas are in grasses and forbs. Urban land does not support vegetation.

This unit makes up about 4 percent of Saipan, 10 percent of Tinian, and less than 1 percent of Aguijan. It is about 50 percent Chinen soils that are very gravelly sandy loam, 25 percent Urban land, and 15 percent Chinen soils that are clay loam. Of minor extent on Saipan is about 10 percent Kagman soils, and on Tinian about 10 percent of mapped areas are Dandan soils and pit areas. On both islands, there are small areas of Takpochao soils.

Chinen soils formed in fill material that was spread over the natural surface of earlier Chinen soils. The surface layer is about 25 centimeters of very gravelly sandy loam fill material. Below this are the buried Chinen soils, which consist of thin very dark grayish brown clay loam over a yellowish red clay loam subsoil. Depth to limestone is about 50 to 75 centimeters.

Urban land consists of paved, impervious areas such as airstrips, roads, buildings, and parking lots.

This unit is used for homesite and urban development, subsistence farming, grazing, wildlife habitat, and watershed. It can be used for recreational development.

This unit is poorly suited to commercial or subsistence farming. It is limited by the very gravelly fill material and the presence of other disturbed areas.

This unit is poorly suited to grazing. The main limitation is droughtiness.

This unit is moderately suited to urban development. The main limitation is the depth to bedrock.

The main limitations for recreational development are droughtiness, the very gravelly surface layer, and the areas of Urban land.

7. Dandan-Chinen

Shallow and moderately deep, well drained, nearly level to strongly sloping soils; on limestone plateaus

This unit is on limestone plateaus on Tinian and Rota. On Tinian, about 75 percent of the unit has slopes of less than 5 percent; on Rota, most slopes are 5 to 15 percent. Slopes are long and plane. The vegetation is mainly forest. Some areas are in grasses and forbs.

This unit makes up about 52 percent of Tinian and about 2 percent of Rota. It is about 45 percent Dandan soils and about 40 percent Chinen soils. Of minor extent are small areas of Takpochao and Saipan soils.

The Dandan soils formed in sediment over porous limestone. Typically, these soils have a very dark brown clay loam and dark brown clay surface layer over a dark reddish brown and reddish brown clay subsoil. Depth to limestone is 50 to 100 centimeters.

The Chinen soils formed in sediment over porous limestone. Typically, these soils have a very dark grayish brown clay loam surface layer 6 centimeters thick over a dark brown clay and yellowish red clay loam subsoil. Depth to limestone is 25 to 50 centimeters.

This unit is used for commercial and subsistence farming, grazing, homesite development, watershed, and wildlife habitat. It can be used for recreational development, for which it is moderately suited.

This unit is moderately suited to commercial and subsistence farming. The main limitations of the Chinen soils are shallow depth and droughtiness. This unit includes some of the best farming areas on Rota and Tinian.

This unit is well suited to grazing. Most of the grazing land on Tinian is in this unit.

The main limitation for urban development is the depth to bedrock.

This unit is underlain by porous limestone. The infiltration of rainwater into the limestone recharges the ground water supplies on Tinian. Forested areas provide habitat for wildlife.

8. Kagman-Saipan

Deep and very deep, well drained, nearly level to strongly sloping soils; on limestone plateaus

This map unit is on limestone plateaus on Saipan and Tinian. About 65 percent of the unit has slopes of less than 5 percent. Other areas have slopes of 5 to 15 percent. Slopes are long and undulating. The vegetation is mainly forest. Some areas are in grasses and forbs or are farmed.

This unit makes up about 9 percent of Saipan and about 3 percent of Tinian. On Saipan, it is about 60 percent Kagman soils, 20 percent Saipan soils, 10 percent Chacha soils, and about 10 percent Chinen soils. Of minor extent are a few small areas of Laolao soils. On Tinian, mapped areas are about 70 percent

Kagman soils, 20 percent Saipan soils, and 10 percent Chinen soils and other soils of minor extent, including Takpochao soils.

The Kagman soils are moderately well drained. These soils formed in sediment more than 100 centimeters thick over limestone. Typically, they have a dark brown clay surface layer about 15 centimeters thick over a slowly permeable strong brown clay subsoil.

The Saipan soils are well drained. These soils formed in sediment more than 100 centimeters thick over limestone. Typically, they have a dark brown and dark reddish brown clay surface layer over a moderately permeable reddish brown and yellowish red clay and silty clay subsoil.

This unit is used for commercial and subsistence farming, grazing, urban development, watershed, and wildlife habitat. It can be used for recreational development.

This unit generally is well suited to farming and grazing, and it includes some of the best farmland in the Northern Marianas. The Kagman soils are limited by wetness during the rainy season.

This unit is moderately suited to homesite and urban development. The main limitations are low soil strength, the moderate shrink-swell potential of the Kagman soils, and slope in some areas. Septic tank absorption fields must be large enough to compensate for the slow permeability of the Kagman soils.

This unit is moderately suited to recreational development. The main limitations are low soil strength and the hazard of compaction when the soil is wet. Compaction adversely affects turf grasses. Soil compaction can be prevented by restricting use during the rainy season.

Forested areas provide habitat for wildlife.

9. Luta

Very shallow, well drained, nearly level to strongly sloping soils; on limestone plateaus

This map unit is on limestone plateaus on Rota. About half of the unit has slopes of less than 5 percent, and the other half has slopes of 5 to 15 percent. Slopes are long and plane. The vegetation is forest in some areas and grasses and forbs in other areas.

This unit makes up about 67 percent of Rota. It is about 85 percent Luta soils and 10 percent limestone Rock outcrop and other components of minor extent, including Takpochao soils on narrow escarpments and exposed coastal plateaus. About 5 percent of the unit is short, steep escarpments that separate different plateau levels.

Luta soils formed in sediment over porous limestone. Typically, these soils are dark brown and brown cobbly clay loam about 15 centimeters deep over limestone. Depth to limestone commonly is 10 to 25 centimeters.

This unit is used for subsistence and commercial farming, grazing, urban and recreational development, watershed, and wildlife habitat.

Most of this unit is poorly suited to farming. It is limited by very shallow soil depth, droughtiness, and the areas of Rock outcrop. About 30 percent of the unit is too rocky to farm. Irrigation is needed in the dry season. Areas on the Sabana are wetter and therefore are moderately suited to farming.

Most areas of this unit are moderately suited to grazing. Because the soils are droughty, forage production is low in the dry season. Many areas are too rocky to clear and manage intensively.

This unit is moderately suited to homesite and urban development. The main limitation is the shallow depth to bedrock. Construction sites are difficult to prepare in areas that include Rock outcrop.

The main limitations for recreational development are very shallow soil depth, droughtiness, cobbles, and areas of Rock outcrop.

This unit is underlain by porous limestone. The infiltration of rainwater into the limestone recharges the ground water supplies on Rota. Forested areas provide habitat for wildlife.

10. Saipan-Dandan

Moderately deep and very deep, well drained, nearly level to gently sloping soils; on limestone plateaus

This map unit is on limestone plateaus on Tinian. About 85 percent of the unit has slopes of less than 5 percent. Other areas have slopes of 5 to 15 percent. The minor Takpochao soils are in the steeper areas, which are short, steep escarpments separating different plateau levels. Small areas of Rock outcrop are also on the escarpments. Slopes are long and plane. The vegetation is forest in some areas and is grasses and forbs in other areas.

This unit makes up about 5 percent of Tinian. It is about 55 percent Saipan soils, 30 percent Dandan soils, 10 percent Chinen soils, and 5 percent Takpochao soils.

The Saipan soils formed in sediment and are more than 100 centimeters deep over porous limestone. Typically, these soils have a dark brown and dark

reddish brown clay surface layer over a reddish brown and yellowish red clay and silty clay subsoil.

The Dandan soils formed in sediment and are 50 to 100 centimeters deep over porous limestone. Typically, these soils have a very dark brown clay loam and dark brown clay surface layer over a dark reddish brown and reddish brown clay subsoil.

This unit is used for commercial and subsistence farming, grazing, watershed, and wildlife habitat. It can be used for urban and recreational development.

This unit is well suited to commercial and subsistence crops, and it includes some of the best farmland in the Northern Marianas. It is limited mainly by small areas of shallow Chinen soils. Irrigation is needed for high yields during the dry season.

This unit is well suited to grazing. It is limited mainly by the low quality of the forage in forested areas.

This unit is moderately suited to both urban and recreational development. The main limitation is low soil strength.

This unit is underlain by porous limestone. The infiltration of rainwater into the limestone recharges the ground water supplies. Forested areas provide habitat for wildlife.

Soils on Uplands

This group consists of three map units. It makes up about 62 percent of Saipan, 5 percent of Tinian, and 25 percent of Rota.

11. Laolao-Akina

Moderately deep, well drained, strongly sloping to steep soils; on volcanic uplands

This unit is on Saipan, Tinian, and Rota. About 40 percent of the unit on Saipan has slopes of 30 to 60 percent. Most of the small areas of this unit on Tinian have slopes of less than 15 percent. On Rota, 65 percent of the unit has slopes of 30 to 60 percent. Slopes are long and irregular and are broken in places by slumps. Many slopes have been deeply dissected by streams. Most areas of Laolao soils are forested, although some areas are in savannah. All areas of Akina soils are in savannah. Areas of Akina soils have many unvegetated slumps or badlands.

This unit makes up about 17 percent of Saipan, 1 percent of Tinian, and 2 percent of Rota. On Saipan, it is about 60 percent Laolao soils, 25 percent Akina soils, and 5 percent Agfayan Variant soils. On Tinian, it is almost entirely Laolao soils. On Rota, about 75 percent of the unit is Laolao soils and most of the rest is Akina soils. The remaining 10 percent is small areas of Chinen, Kagman, and Takpochao soils.

The Laolao soils formed in residuum derived from andesitic marine tuff and tuffaceous sandstone. Typically, these soils have a dark reddish brown and dark brown clay surface layer over a red or dark red clay subsoil. Soft volcanic saprolite is at a depth of 50 to 100 centimeters. The profile is strongly acid to neutral and has a moderate amount of calcium.

The Akina soils formed in residuum derived from tuff or tuff breccia. Typically, these soils have a dark reddish brown and dark brown clay surface layer over a red or dark red clay subsoil. Soft volcanic saprolite is at a depth of 50 to 100 centimeters. The profile is strongly acid throughout and is low in bases such as calcium.

This unit is used for commercial and subsistence farming, homesites, wildlife habitat, and watershed. It can be used for grazing and recreational development.

The main limitations for farming are slope and the low fertility of the Akina soils. About 25 percent of the unit is suitable for commercial farming. Tree crops can be grown in the steeper areas of Laolao soils.

The main limitations for grazing are slope in some areas and the poor quality of the forage. The savannah grasses generally are of poor quality.

The main limitations for urban development are the steepness of slope and low soil strength.

The main limitation for recreational development is slope. Exposed subsoil material is difficult to revegetate.

Most of the streams in the Northern Marianas are on or near this unit. The plant cover on the soils affects the quality and flow of the water in these streams. Wildfires adversely affect the water quality by removing the plant cover, thereby exposing the soils to erosion. The watershed can be improved by preventing wildfires and planting adapted forest trees. These practices will also improve the habitat for wildlife.

12. Rock Outcrop-Takpochao-Luta

Shallow and very shallow, well drained, strongly sloping to extremely steep soils, and Rock outcrop; on limestone escarpments

This map unit is on Rota. Rock outcrop generally dominates the steeper areas, and Takpochao and Luta soils are between the areas of Rock outcrop. Slopes are irregular and abrupt, and there are many vertical cliff faces and narrow benches. The vegetation is native forest.

This unit makes up about 23 percent of Rota. It is about 40 percent Rock outcrop, 35 percent Takpochao soils, and 25 percent Luta soils.

Rock outcrop consists of white, porous limestone

derived from coral reef formations. The surface is jagged and irregular.

The Takpochao soils are shallow. They formed in sediment overlying porous limestone at a depth of 10 to 40 centimeters. Typically, these soils have a black and very dark grayish brown very cobbly clay surface layer over a dark yellowish brown very cobbly clay subsoil.

The Luta soils are very shallow. They formed in sediment overlying porous limestone at a depth of 10 to 25 centimeters. Typically, these soils have a dark brown cobbly clay loam surface layer over a brown cobbly clay loam subsoil.

This unit is used as watershed and wildlife habitat. A few areas are grazed.

Farming on this unit is feasible only on the narrow benches where slope is less than 15 percent, and many of these areas are too rocky to farm.

Grazing is severely restricted by the steepness of slope.

Homesite development is feasible only on the few narrow, gently sloping benches. Rock outcrop interferes with site preparation in these areas.

Native forests, rugged cliff lines, and panoramic vistas are characteristic of this unit. Recreational development can use these natural assets. Trails, campsites, and scenic viewpoints can be established.

This unit provides important wildlife habitat to cliff-dwelling species such as fruit bats and certain birds. The extensive native forest provides habitat for many wildlife species.

13. Takpochao-Chinen-Rock Outcrop

Shallow, well drained, strongly sloping to extremely steep soils, and Rock outcrop; on limestone escarpments and plateaus

This map unit is on Saipan, Tinian, and Aguijan. About 50 percent of the unit has slopes of 15 to 30 percent. Takpochao soils generally are in the steeper areas, such as on escarpments, as well as on exposed coastal benches. Chinen soils generally are on narrow benches and small plateaus, but they also are in the steeper areas. Rock outcrop is closely associated with the Takpochao soils, but it is present in some areas of Chinen soils as well. Vertical cliffs are common. The Saipan soils are in small pockets on isolated benches. Slopes are irregular and abrupt, and there are many vertical cliff faces and narrow benches. The vegetation is mainly forest.

This unit makes up about 45 percent of Saipan, 4 percent of Tinian, and 30 percent of Aguijan. On Saipan, it is about 35 percent Takpochao very cobbly soils, 35 percent Chinen soils, 20 percent Rock outcrop, and 8 percent Saipan soils. Of minor extent are small areas of Kagman and Chacha soils. On Tinian, this unit is about 40 percent Takpochao soils, 30 percent Chinen soils, 25 percent Rock outcrop, and 5 percent Saipan soils. Takpochao soils and Rock outcrop are dominant on Aguijan, where there is less than 20 percent Chinen soils.

The Takpochao soils formed in sediment over porous limestone. Typically, these soils are black and very dark grayish brown very cobbly clay. Limestone is at a depth of 10 to 40 centimeters. An intermittent dark yellowish brown subsoil is present in pockets in the limestone.

The Chinen soils formed in sediment over porous limestone. Typically, these soils have a very dark grayish brown clay loam surface layer over a dark brown and yellowish red clay loam subsoil. Limestone is at a depth of 25 to 50 centimeters.

Rock outcrop consists of white, porous limestone derived from coral reef formations. The surface is jagged and irregular.

This unit is used for subsistence farming, homesite development, recreational development, watershed, and wildlife habitat.

Commercial and subsistence farming is feasible only in scattered gently sloping areas of Chinen and Saipan soils. More than 80 percent of the unit is too steep or rocky for farming.

Most of the unit is poorly suited to grazing. Steepness of slope and the areas of Rock outcrop are limitations.

Most of this unit is not suitable for homesite development. Steepness of slope, the areas of Rock outcrop, and shallow soil depth are the main limitations. Homesites can be located on isolated benches.

Native forests, rugged cliff lines, and panoramic vistas are characteristic of this unit. Recreational development can incorporate these natural assets. Trails, campsites, and scenic viewpoints can be established.

This unit provides important wildlife habitat to cliff-dwelling species such as fruit bats and certain birds. The extensive native forest provides habitat for many wildlife species.

Broad Land Use Considerations

Agriculture, grazing, urbanization, recreation, watershed, and wildlife habitat are the major land uses in the survey area. The soils in the area vary widely in their potential for these uses.

Although farming is economically and culturally

Figure 3.—Luta soils in foreground are used for grazing. Takpochao soils in background are under native forest.

important, less than 1 percent of the land is actually under cultivation at any one time. Most of this land is in general soil map units 5 and 8 on Saipan; units 4, 7, 8, and 10 on Tinian; and unit 9 on Rota. The Banaderu soils of unit 4, the Chinen soils of units 5 and 7, and the Luta soils of unit 9 are all moderately suited to farming. These soils are shallow and have low available water capacity. Most areas of the very shallow Luta soils of unit 9 are poorly suited to farming, although units on the Sabana are moderately suited. The Dandan soils of units 7 and 10, the Kagman soils of unit 8, and the Saipan soils of units 8 and 10 are well suited to farming. Wetness during the rainy season limits field access on the Kagman soils. Soils in unit 1 generally are too wet for farming. Soils in units 2 and 3 are droughty, although the Shioya soils can be farmed with irrigation. Unit 6 is heavily urbanized. Units 11, 12, and 13 generally are too steep for farming.

About 20 percent of the Northern Marianas is classified as rangeland or pastureland, although much of the rangeland is not actually grazed. Most of the native savannah is in unit 13, and there is very little

grazing on this unit. Most grazing is on unit 5 on Saipan, units 7 and 8 on Tinian, and unit 9 on Rota. Units 2, 3, 4, 5, 7, 8, 9, and 10 generally are moderately to well suited to grazing (fig. 3), although available forage is very low in many areas. Unit 1 is too wet, unit 6 is urbanized, and most areas in units 11, 12, and 13 are too steep.

Most urbanization is on units 2 and 6 on Saipan and unit 6 on Tinian. Much of this urban land is abandoned military facilities. Most soils in units 2, 3, 4, 5, 6, 7, 8, 9, and 10 are moderately suited to urban use. The main limitation on the Banaderu, Chinen, and Luta soils is the shallow or very shallow depth to bedrock, which interferes with excavation. Rock outcrop is a limitation on many units. The main limitation on the Dandan, Kagman, and Saipan soils is low soil strength. Unit 1 is

Figure 4.—View of Bird Island, which has an intermittent cover of Agfayan Variant soils. Although this area is unsuitable for intensive use, its scenic value constitutes an important land use on Saipan.

too wet for urbanization, and units 11, 12, and 13 generally are too steep.

Recreational development is a major land use on units 2, 5, and 8 on Saipan and on unit 3 on Rota. There is a large potential for recreational development on the islands, ranging from intensive uses such as roadside parks, ball fields, and golf courses to extensive uses such as hiking trails. The Shioya soils in units 2 and 3 are well suited to beach parks, but facilities must be protected from high winds and surf. Level areas in units 4, 5, 6, 7, 8, 9, and 10 are moderately suited for ball fields. Limitations include seasonal wetness on the Kagman soils and surface cobbles on the Luta soils. Areas of Takpochao soils and Rock outcrop should be avoided. All of these units have good potential for golf course development except for unit 6, which is heavily urbanized. Units 11, 12, and 13 generally are too steep for hiking trails and scenic overlooks (fig. 4). Unit 1 is limited by wetness, but Hagoi Susupe on Saipan provides a possibility for swimming and use of small sailboats or canoes.

Most of the land on the islands is undeveloped and is used as wildlife habitat and watershed. Officially designated areas of wildlife habitat include Aguijan Island and the Commonwealth Forests on Saipan and Rota. Watersheds of recognized importance include the Sabana area on Rota (unit 9), the slopes surrounding the Makpo wells on Tinian (unit 12), and the easterly slopes of Mount Takpochao on Saipan (unit 12). Unit 1 provides virtually all of the wetland wildlife habitat in the Northern Marianas, including habitat for such endangered species as the Marianas gallinule. Forest cover in all units provides habitat for forest birds, deer, and other species.

Detailed Soil Map Units

The map units delineated on the detailed maps at the back of this survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this section, along with the maps, can be used to determine the suitability and potential of a unit for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit is given under "Use and Management of the Soils."

A map unit delineation on a map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils or miscellaneous areas. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils and miscellaneous areas are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some "included" areas that belong to other taxonomic classes.

Most included soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, inclusions. They may or may not be mentioned in the map unit description. Other included soils and miscellaneous areas, however, have properties and behavior divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, inclusions. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. The included areas of contrasting soils or miscellaneous areas are mentioned in the map unit descriptions. A few included areas may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of included areas in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but if intensive use of small areas is planned, onsite investigation to precisely define and locate the soils and miscellaneous areas is needed.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the underlying layers, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the underlying layers. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Kagman clay, 5 to 15 percent slopes, is one of several phases in the Kagman series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes.

A *complex* consists of two or more soils or

miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Dandan-Chinen complex, 0 to 5 percent slopes, is an example.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Table 1 gives the hectarage and proportionate extent of each map unit. Other tables (see "Summary of Tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils or miscellaneous areas.

1—Agfayan Variant-Rock outcrop complex, 15 to 30 percent slopes. This map unit is on volcanic uplands on the island of Saipan. Slopes are long and plane but are broken in some areas by rock benches and escarpments. The vegetation on the Agfayan Variant soil is mainly grasses and forbs with scattered trees. Rock outcrop is not vegetated. Elevation is sea level to 160 meters.

This unit is 55 percent Agfayan Variant very cobbly clay and 30 percent Rock outcrop. The components of this unit are so intricately intermingled that it was not feasible to map them separately at the scale used.

Included in this unit are small areas of Akina and Laolao soils in concave areas, clayey soils, and sandy spots along the coast. Also included are nearly level benches; soils that have short, steep slopes; and areas that were disturbed during World War II. Included areas make up about 15 percent of the total hectarage.

The Agfayan Variant soil is very shallow and well drained. It formed in residuum and colluvium derived dominantly from dacite and andesitic tuff. Typically, about 50 percent of the soil surface is covered by pebbles and cobbles and about 3 percent is covered by stones. The surface layer is very dark gray very cobbly clay about 16 centimeters thick. Below this to a depth of 35 centimeters is dark grayish brown cobbly clay loam over firm, weathered dacite. Depth to firm dacite ranges from 25 to 50 centimeters.

Permeability of the Agfayan Variant soil is moderate. Effective rooting depth is 10 to 50 centimeters. Available water capacity is low. Runoff is rapid, and the hazard of water erosion is severe. A perched water table is present above the bedrock in some areas for brief periods following heavy rains.

Rock outcrop is hard to very hard, light gray dacite and andesitic tuff. The surface of the Rock outcrop generally is smooth and even. It can be chipped with a spade. Cracks and seams are common. Water penetrates the areas of Rock outcrop only along cracks and seams. Runoff is very rapid. Rock outcrop is resistant to erosion.

This unit is used as watershed and wildlife habitat. It can be used for grazing, subsistence farming, and homesite and recreational development.

This unit is unsuited to commercial farming. It is limited by steepness of slope, shallow soil depth, areas of Rock outcrop, and the severe hazard of erosion.

This unit is poorly suited to subsistence farming. It is limited by the areas of Rock outcrop, severe hazard of erosion, shallow soil depth, and droughtiness. Fruit trees and other deep-rooted plants are not suited to the unit. Crops can be planted only at irregular intervals between the areas of Rock outcrop. Vehicle access and mechanical tillage are restricted by the areas of Rock outcrop and steepness of slope. Clean cultivation should be avoided. Irrigation is necessary during the dry season.

This unit is poorly suited to grazing. The main limitations are the areas of Rock outcrop, hazard of gully erosion, and droughtiness. Using proper stocking rates and rotation grazing prevents extensive trailing. Stocking rates should be adjusted to the amount of forage available.

This unit is poorly suited to homesite and urban development. The main limitations are the steepness of slope, areas of Rock outcrop, and shallow depth to bedrock. Excavation is difficult because of the very shallow depth to bedrock. Septic tank absorption fields will not function properly because of the depth to dense bedrock.

This unit is poorly suited to recreational development. The severe hazard of erosion, steepness of slope, and areas of Rock outcrop limit use of this unit to a few paths and trails.

The Agfayan Variant soil is in capability subclass VIe, and Rock outcrop is in capability subclass VIIIs.

2—Agfayan Variant-Rock outcrop complex, 30 to 60 percent slopes. This map unit is on volcanic uplands on the island of Saipan. Slopes are long and plane but are broken in some areas by rock benches and escarpments. The vegetation on the Agfayan Variant soil is mainly grasses and forbs with scattered trees. Rock outcrop is not vegetated. Elevation is sea level to 160 meters.

This unit is 55 percent Agfayan Variant very cobbly clay and 30 percent Rock outcrop. The components of this unit are so intricately intermingled that it was not

feasible to map them separately at the scale used.

Included in this unit are small areas of Akina and Laolao soils in concave areas, clayey soils, and sandy spots along the coast. Also included are nearly level benches; soils that have short, steep slopes; and areas that were disturbed during World War II. Included areas make up about 15 percent of the total hectarage.

The Agfayan Variant soil is very shallow and well drained. It formed in residuum and colluvium derived dominantly from dacite and andesitic tuff. About 50 percent of the soil surface is covered by pebbles and cobbles, and about 3 percent is covered by stones. Typically, the surface layer is very dark gray very cobbly clay about 16 centimeters thick. Below this to a depth of 35 centimeters is dark grayish brown cobbly clay loam over firm, weathered dacite. Depth to dacite ranges from 25 to 50 centimeters.

Permeability of the Agfayan Variant soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is rapid, and the hazard of water erosion is severe. A perched water table is present above the bedrock in some areas for brief periods following heavy rains.

Rock outcrop is hard to very hard, light gray dacite and andesitic tuff. The surface of the areas of Rock outcrop commonly is smooth and even. It can be chipped with a spade. Cracks and seams are common. Water penetrates the areas of Rock outcrop only along cracks and seams. Runoff is very rapid. The Rock outcrop is resistant to erosion.

This unit is used as watershed and wildlife habitat. It can be used for grazing, subsistence farming, and homesite and recreational development.

This unit is unsuited to commercial farming. It is limited by the steepness of slope, shallow soil depth, areas of Rock outcrop, and severe hazard of erosion.

This unit is poorly suited to subsistence farming. It is limited by the areas of Rock outcrop, severe hazard of erosion, very shallow soil depth, and droughtiness. Fruit trees and other deep-rooted plants are not suited to the unit.

This unit is poorly suited to grazing. The main limitations are the areas of Rock outcrop, the hazard of gully erosion, and droughtiness.

This unit is poorly suited to homesite and urban development. The main limitations are the steepness of slope, areas of Rock outcrop, and very shallow depth to bedrock.

This unit is poorly suited to recreational development. The steepness of slope and areas of Rock outcrop limit use of this unit to a few paths and trails.

The Agfayan Variant soil is in capability subclass VIIe, and Rock outcrop is in capability subclass VIIIs.

3—Akina-Badland complex, 15 to 30 percent slopes. This map unit is on volcanic uplands on the islands of Saipan and Rota. Slopes are long and plane. Short, steep dropoffs and ravines are present in the areas of Badland. The vegetation on the Akina soil is mainly grasses and forbs. The areas of Badland support little or no vegetation. Elevation is sea level to 160 meters.

This unit is 60 percent Akina clay and 30 percent Badland. The Akina soil is on stabilized, vegetated ridgelines and side slopes. The areas of Badland are in slumps, ravines, and disturbed areas that are not vegetated. Areas of Badland are throughout the unit but are most commonly on shoulder slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Akina soils that have an eroded surface layer, Laolao and Agfayan Variant soils, and soils that are moderately deep to impervious tuffaceous sandstone. Also included are small areas of nearly level soils on benches and ridgetops and soils that have short, steep slopes. Included areas make up about 10 percent of the total hectarage.

The Akina soil is moderately deep and well drained. It formed in residuum derived dominantly from volcanic tuff and tuff breccia. Typically, the surface layer is dark brown silty clay about 4 centimeters thick over dark reddish brown clay about 11 centimeters thick. The subsoil is red and dark red clay about 55 centimeters thick. The substratum to a depth of 84 centimeters is variegated dark red and red clay. The profile is strongly acid throughout. Strongly weathered tuffaceous material is at a depth of 84 centimeters. Depth to saprolite dominantly ranges from 50 to 100 centimeters.

Permeability of the Akina soil is moderately slow. Effective rooting depth is 50 to 100 centimeters. Available water capacity is moderate. Runoff is rapid, and the hazard of water erosion is severe.

Badland is areas of very deep, well drained saprolite derived from volcanic tuff and tuff breccia. These areas are actively eroding. Gullies and ravines are common. The saprolite is variegated dark red and white, and it can be easily crushed to silty clay or clay. Permeability is slow. Runoff is rapid, and the hazard of water erosion is severe.

This unit is used mainly as wildlife habitat and watershed. It is also used for off-road vehicle recreation. It can be used for grazing, subsistence

farming, and homesite and recreational development.

This unit is unsuited to commercial farming because of the steepness of slope, severe hazard of erosion, and areas of Badland.

This unit is poorly suited to subsistence farming. It is limited by the areas of Badland, severe hazard of erosion, and soil acidity. Clean cultivation should be avoided. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce acidity.

This unit is poorly suited to grazing. The main limitations are the areas of Badland and hazard of gully erosion. The areas of Badland do not produce forage. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is poorly suited to homesite and urban development. The main limitations are the areas of Badland, steepness of slope, severe hazard of erosion, and low soil strength. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as feasible help to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Growth of the natural revegetation is poor on the exposed subsoil material and saprolite. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing roads.

This unit is poorly suited to recreational development. The steepness of slope and areas of Badland limit use of this unit to a few path and trails.

The Akina soil is in capability subclass VIe, and Badland is in capability subclass VIIIe.

4—Akina-Badland complex, 30 to 60 percent slopes. This map unit is on volcanic uplands on the islands of Saipan and Rota. Slopes are long and plane. Short, very steep dropoffs and ravines are present in the areas of Badland. The vegetation on the Akina soil is mainly grasses and forbs. The areas of Badland support little vegetation. Elevation is sea level to 330 meters.

This unit is 60 percent Akina clay and 30 percent Badland. The Akina soil is on stabilized, vegetated ridgelines and side slopes. The areas of Badland are in slumps, ravines, and disturbed areas that are not vegetated. These areas are throughout the unit but are most commonly on shoulder slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Akina soils that have an eroded surface layer, Laolao and Agfayan Variant soils, and soils that are moderately deep to impervious tuffaceous sandstone. Also included are small areas of gently sloping to moderately steep soils on ridgetops and side slopes and soils that have short, extremely steep slopes. Included areas make up about 10 percent of the total hectarage.

The Akina soil is moderately deep and well drained. It formed in residuum derived dominantly from volcanic tuff and tuff breccia. Typically, the surface layer is dark brown silty clay about 15 centimeters thick over dark reddish brown clay about 11 centimeters thick. The subsoil is dark red clay about 55 centimeters thick. The substratum to a depth of 84 centimeters is variegated dark red and red clay. Strongly weathered tuffaceous material is at a depth of 84 centimeters. The profile is strongly acid throughout. Depth to saprolite dominantly ranges from 50 to 100 centimeters.

Permeability of the Akina soil is moderately slow. Effective rooting depth is 50 to 100 centimeters. Available water capacity is moderate. Runoff is rapid, and the hazard of water erosion is very severe.

Badland is areas of very deep, well drained saprolite derived from volcanic tuff and tuff breccia. These areas are actively eroding. Gullies and ravines are common. The saprolite is variegated dark red and white, and it can be easily crushed to silty clay or clay. Permeability is slow. Runoff is rapid, and the hazard of water erosion is very severe.

This unit is used as wildlife habitat and watershed. It can also be used for grazing and recreational development.

The unit is unsuited to commercial and subsistence farming or to homesite development because of the steepness of slope, very severe hazard of erosion, and areas of Badland.

This unit is poorly suited to grazing. The main limitations are the areas of Badland, hazard of gully erosion, and steepness of slope. The areas of Badland do not produce forage. Using proper stocking rates and rotation grazing prevents extensive trailing. Careful fence line placement will encourage uniform grazing on the steeper slopes.

This unit is poorly suited to recreational development. The steepness of slope and areas of Badland limit use of this unit to a few paths and trails.

The Akina soil is in capability subclass VIIe, and Badland is in capability subclass VIIIe.

5—Banaderu clay loam, 3 to 5 percent slopes. This shallow, well drained soil is on uplifted limestone plateaus on the islands of Saipan and Tinian. It formed in sediment over porous coralline limestone. Slopes are long and undulating. The vegetation is mainly secondary forest. Elevation is 100 to 200 meters.

Typically, the surface layer is black clay loam about 18 centimeters thick. The subsoil is dusky red and dark red clay about 30 centimeters thick over jagged and irregular limestone. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Included in this unit are small areas of limestone Rock outcrop and soils that are less than 25 centimeters or more than 50 centimeters deep to limestone. Also included are small areas that were disturbed during World War II; these areas are covered with limestone gravel fill and piles of concrete and other rubble. Included areas make up about 15 percent of the total area.

Permeability of this Banaderu soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for commercial farming, grazing, watershed, and wildlife habitat. It can be used for subsistence farming, recreation, and homesite development.

This unit is moderately suited to commercial farming; however, fruit trees and other deep-rooted plants are poorly suited to the unit. It is limited mainly by the shallow soil depth and droughtiness. Pinnacles of the underlying limestone are within the plow zone in many places, which affects tillage. Irrigation is necessary during the dry season for high yields of vegetables and for maximum production of field crops. Even during the rainy season, short dry periods will stress vegetable crops that are not irrigated. Because the Banaderu soil is droughty, light and frequent applications of irrigation water are needed.

This unit is moderately suited to subsistence farming. Fruit trees and banana plants can be grown in the scattered, moderately deep pockets of soil. The limestone can be excavated to widen these pockets.

This unit is well suited to grazing. The main limitation is droughtiness. Stocking rates should be adjusted to the amount of forage available.

This unit is moderately suited to homesite and urban development. The main limitations are the shallow depth to bedrock and low soil strength. Excavation is difficult because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing roads.

This unit is moderately suited to recreational development. The main limitations are the shallow soil depth and droughtiness.

This map unit is in capability subclass IVs.

6—Banaderu clay loam, 5 to 15 percent slopes. This shallow, well drained soil is on uplifted limestone plateaus on the island of Saipan. It formed in sediment over porous coralline limestone. Slopes are long and concave. The vegetation is mainly secondary forest. Elevation is 150 to 250 meters.

Typically, the surface layer is black clay loam about 18 centimeters thick. The subsoil is dusky red and dark red clay about 30 centimeters thick over jagged and irregular limestone. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Included in this unit are limestone Rock outcrop, soils that are less than 25 centimeters or more than 50 centimeters deep to limestone, Chinen soils, nearly level soils on benches, and soils that have short, moderately steep slopes. Also included are small areas of soils that were disturbed during World War II and are covered with limestone gravel fill, piles of concrete, and other rubble. Included areas make up about 15 percent of the total hectarage.

Permeability of this Banaderu soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used for grazing and as watershed and wildlife habitat. It can be used for commercial and subsistence farming, recreation, and homesite development.

This unit is moderately suited to commercial farming; however, fruit trees and other deep-rooted plants are poorly suited to the unit. It is limited mainly by the moderate hazard of erosion, shallow depth to bedrock, and droughtiness. An erosion control system that includes contour farming, mulching, diversions, terraces, hillside ditches, and grassed waterways may be needed. Included areas that are underlain by pinnacles of limestone may affect tillage. Irrigation is necessary during the dry season for growing vegetables and for maximum production of field crops. Even during the rainy season, short dry periods will stress vegetable crops that are not irrigated. Because the Banaderu soil is droughty, light and frequent applications of irrigation water are needed.

This unit is moderately suited to subsistence farming. It is limited mainly by the shallow depth to bedrock, droughtiness, and moderate hazard of erosion. Fruit trees and banana plants can be grown in the scattered included areas of moderately deep soils. The underlying

limestone can be excavated to widen these areas. Clean cultivation should be avoided where feasible.

This unit is well suited to grazing. The main limitations are the hazard of gully erosion on livestock trails and droughtiness. Stocking rates should be adjusted to the amount of forage available. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is moderately suited to homesite and urban development. The main limitations are the shallow depth to bedrock, steepness of slope, moderate hazard of erosion, and low soil strength. Excavation is difficult because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as feasible help to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing roads.

This unit is moderately suited to recreational development. The main limitations are the shallow soil depth, steepness of slope, and droughtiness. Cuts and fills are needed to establish playgrounds, ball fields, and other areas that require extensive level slopes.

This map unit is in capability subclass IVe.

7—Banaderu-Rock outcrop complex, 5 to 15 percent slopes. This map unit is on uplifted limestone plateaus on the islands of Saipan and Tinian. Slopes are long and concave. The vegetation is mainly native forest. Elevation is 100 to 250 meters.

This unit is 55 percent Banaderu clay loam and 35 percent Rock outcrop. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are soils that are less than 25 centimeters or more than 50 centimeters deep to limestone, Chinen soils, nearly level soils on benches, and soils that have short, moderately steep slopes. Also included are small areas of soils that were disturbed during World War II and are covered by limestone gravel fill, piles of concrete, and other rubble. Included areas make up about 10 percent of the total hectarage.

The Banaderu soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is black clay loam about 18 centimeters thick. The subsoil is dusky red and dark red clay about 30 centimeters thick over jagged, irregular limestone. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Permeability of this Banaderu soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is moderate.

The Rock outcrop is white, porous coralline limestone. The surface is jagged and irregular. Organic debris, soil material, and roots are in cracks and interstices. Permeability is rapid, and runoff is very rapid.

This unit is used for grazing and as watershed and wildlife habitat. It can be used for subsistence farming, recreation, and homesite development.

This unit is unsuited to commercial farming. It is limited by the areas of Rock outcrop, shallow soil depth, droughtiness, and moderate hazard of erosion.

This unit is poorly suited to subsistence farming. It is limited mainly by the areas of Rock outcrop, shallow soil depth, droughtiness, and moderate hazard of erosion. Crops can be planted only at irregular intervals between the areas of Rock outcrop. Vehicle access and mechanical tillage are restricted by the areas of Rock outcrop. Fruit trees can be planted in the scattered included areas of moderately deep soils. The underlying limestone can be excavated to widen these areas. Clean cultivation should be avoided. Irrigation is necessary during the dry season.

This unit is poorly suited to grazing. The main limitations are the areas of Rock outcrop, hazard of gully erosion on livestock trails, and droughtiness. The areas of Rock outcrop limit the pasture management practices that can be used. Most areas of this unit are heavily forested, and forage production is very low.

This unit is poorly suited to homesite and urban development. The main limitations are the areas of Rock outcrop, shallow soil depth, and steepness of slope. Excavation is difficult because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. Preserving the existing plant cover during construction helps to control erosion. Soil material can be stockpiled and used to reclaim areas disturbed during construction. These areas can be revegetated to control erosion.

This unit is poorly suited to recreational development. The main limitation is the areas of Rock outcrop. These areas limit use of this unit to a few paths and trails.

The Banaderu soil is in capability subclass IVe, and

Rock outcrop is in capability subclass VIIIs.

8—Banaderu-Rock outcrop complex, 15 to 30 percent slopes. This map unit is on uplifted limestone plateaus on the island of Saipan. Slopes are long and plane. The vegetation is mainly native forest. Elevation is 150 to 250 meters.

This unit is 50 percent Banaderu clay loam and 35 percent Rock outcrop. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of soils that are less than 25 centimeters or more than 50 centimeters deep to limestone, Chinen soils, vertical cliff faces, soils on gently sloping benches, and soils on short, steep slopes. Also included are small areas of soils that were disturbed during World War II and are characterized by bulldozed areas, areas of limestone gravel fill, and piles of concrete and other rubble. Included areas make up about 15 percent of the total hectarage.

The Banaderu soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is black clay loam about 18 centimeters thick. The subsoil is dusky red and dark red clay about 30 centimeters thick over jagged and irregular limestone. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Permeability of the Banaderu soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is severe.

The Rock outcrop is white, porous coralline limestone. The surface is jagged and irregular. Organic debris, soil material, and roots are in cracks and interstices. Runoff is very rapid.

This unit is used for grazing and as watershed and wildlife habitat. It can be used for subsistence farming and recreational development.

This unit is unsuited to commercial farming and homesite development. It is limited by the areas of Rock outcrop and steepness of slope.

This unit is poorly suited to subsistence farming. It is limited mainly by the areas of Rock outcrop, severe hazard of erosion, shallow soil depth, and droughtiness. Crops can be planted only at irregular intervals between the Rock outcrop. Vehicle access and mechanical tillage are restricted by the areas of Rock outcrop and steepness of slope. Fruit trees and banana plants can be grown in the scattered included pockets of moderately deep soils. The limestone can be excavated to widen these pockets. Clean cultivation should be avoided where feasible. Irrigation is necessary during the drier parts of the year.

This unit is poorly suited to grazing. The main limitations are the areas of Rock outcrop, hazard of gully erosion on livestock trails, and droughtiness. The areas of Rock outcrop and steepness of slope limit the pasture management practices that can be used. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion. Most areas of this unit are heavily forested, and forage production is very low.

This unit is poorly suited to recreational development. The main limitations are the areas of Rock outcrop and steepness of slope, which restrict use of this unit to a few paths and trails.

The Banaderu soil is in capability subclass VIe, and Rock outcrop is in capability subclass VIIIs.

9—Chacha clay, drained, 0 to 5 percent slopes. This deep, somewhat poorly drained soil is in broad depressional areas on rolling limestone plateaus on the islands of Saipan and Tinian. The soil is artificially drained using a series of ditches. It formed in sediment derived dominantly from coralline limestone. Slopes are long and concave. The vegetation is mainly grasses and secondary forest. Elevation is 60 to 80 meters.

Typically, the surface layer is dark yellowish brown clay about 17 centimeters thick. It has many black manganese concretions. The subsoil to a depth of 100 centimeters is mottled, strong brown clay. It has many black manganese concretions in the upper part. The substratum to a depth of more than 150 centimeters is mixed strong brown, dark red, and light gray clay.

Included in this unit are Kagman and Saipan soils and somewhat poorly drained soils in depressional areas.

Permeability of this Chacha soil is slow. Effective rooting depth is more than 150 centimeters. Available water capacity is moderate. Runoff is ponded or very slow, and the hazard of water erosion is slight. A water table is present in some places below a depth of 100 centimeters during the rainy season. Level areas are ponded following storms.

This unit is used for commercial and subsistence farming, grazing, homesite development, watershed, and wildlife habitat. It can also be used for recreation.

This unit is well suited to commercial and subsistence farming. It is limited mainly by wetness during the rainy season and a hazard of compaction when the soil is moist. Because of the periodic ponding and soil wetness, field access is not feasible during most of the rainy season. Crops that are sensitive to

wetness or that require frequent attention can be grown only during the dry season. Using raised beds for crops helps to overcome the problem of wetness. The ditches that are used to remove excess water should be cleaned and maintained on a regular basis. To prevent soil compaction, field operations should be avoided after heavy rains. All tillage should be across the slope.

This unit is well suited to grazing. The main limitations are the hazard of soil compaction when the soil is moist and the lack of forage in forested areas. Cleared areas are suited to seeding with adapted forage plants. Livestock should be removed when the soil is ponded.

This unit is moderately suited to homesite and urban development. The main limitations are low soil strength and wetness during the rainy season. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing buildings and roads. Although drainage ditches are present in most areas, additional ditches may be needed to remove excess water. Septic tank absorption fields do not function properly because of the seasonal high water table.

This unit is moderately suited to recreational development. The main limitations are low soil strength and a hazard of compaction when the soil is moist. Compaction adversely affects growth of turf grasses.

This map unit is in capability subclass IIw.

10—Chinen clay loam, 0 to 5 percent slopes. This shallow, well drained soil is on limestone plateaus on the islands of Saipan, Tinian, and Aguijan. It formed in sediment over porous crystalline limestone. Slopes are long and plane. The vegetation is mainly secondary forest. Elevation is 10 to 450 meters.

Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick. The subsoil is dark brown clay about 12 centimeters thick over yellowish red clay loam about 17 centimeters. Jagged, irregular limestone is at a depth of 35 centimeters. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Included in this unit are small areas of Dandan, Saipan, Takpochao, and Kagman soils; soils that have short, steep slopes, soils that are less than 25 centimeters or more than 50 centimeters deep to bedrock; and vertical cliffs along the coast. Also included are small areas of sandy spots along the coast, limestone quarries, and soils that were disturbed during World War II and are characterized by limestone gravel fill and piles of concrete and other rubble. Included areas make up about 20 percent of the total hectarage.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for commercial and subsistence farming, grazing, recreation, homesite development, watershed, and wildlife habitat.

This unit is moderately suited to commercial farming. Fruit trees and other deep-rooted plants are not suited to the unit. It is limited mainly by shallow soil depth and droughtiness. Included pinnacles of underlying limestone are within the plow zone in many places and thus affect tillage. Irrigation is needed during the dry season for production of vegetables and for maximum production of field crops. Even during the rainy season, short dry periods will stress vegetable crops that are not irrigated. Because the soil in this unit is droughty, light and frequent applications of irrigation water are needed. All tillage should be across the slope.

The limitations for subsistence farming are similar to those for commercial farming. Fruit trees can be planted in the scattered included pockets of moderately deep soils. The limestone can be excavated to widen these pockets.

This unit is well suited to grazing. The main limitations are droughtiness and lack of forage in forested areas. Stocking rates should be adjusted to the amount of forage available.

This unit is moderately suited to homesite and urban development. The main limitations are the shallow depth to bedrock and low soil strength. Excavation is difficult because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing roads.

This unit is moderately suited to recreational development. The main limitations are the shallow soil depth and droughtiness.

This map unit is in capability subclass IIIs.

11—Chinen clay loam, 5 to 15 percent slopes. This shallow, well drained soil is on plateaus on all the islands in the survey area. It formed in sediment over porous coralline limestone. Slopes are long and plane. The vegetation is mainly secondary forest. Elevation is 10 to 450 meters.

Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick. The subsoil

is dark brown clay about 12 centimeters thick over yellowish red clay loam about 17 centimeters thick. Jagged, irregular limestone is at a depth of 35 centimeters. Pinnacles of limestone are at a depth of less than 25 centimeters. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Included in this unit are small areas of Dandan, Saipan, Takpochao, and Kagman soils; Rock outcrop; soils that have short, steep slopes; soils that are less than 25 centimeters or more than 50 centimeters deep to limestone; vertical cliffs along the coast; and soils that have a very sticky clay subsoil. Also included on Saipan and Tinian are small areas of soils that were disturbed during World War II. These areas are characterized by bulldozed areas, limestone gravel fill, and piles of concrete and other rubble. On Rota there are small areas of Luta soils and areas of very sticky clay soils. Included areas make up about 20 percent of the total hectarage.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used for subsistence farming, grazing, homesite development, watershed, and wildlife habitat. It can be used for commercial farming and recreation.

This unit is moderately suited to commercial vegetable and field crop production. It is not suited to fruit trees and other deep-rooted plants. The unit is limited mainly by shallow soil depth, moderate hazard of erosion, and droughtiness. Irrigation is necessary during the dry season for vegetables and for maximum production of field crops. Even during the rainy season, short dry periods will stress vegetable crops that are not irrigated. Because the soil in this unit is droughty, light and frequent applications of irrigation water are needed.

The limitations for subsistence farming are similar to those for commercial farming. Fruit trees and banana plants can be grown in the included scattered pockets of moderately deep soils. The limestone can be excavated to widen these pockets. Clean cultivation should be avoided.

This unit is well suited to grazing. The main limitations are the hazard of gully erosion on livestock trails and droughtiness. Stocking rates should be adjusted to the amount of forage available. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is moderately suited to homesite and urban development. The main limitations are the shallow depth to bedrock, steepness of slope, moderate hazard of erosion, and low soil strength. Excavation is difficult because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. Preserving the existing plant cover during construction helps to control erosion. Soil material can be stockpiled and used to reclaim areas disturbed during construction. These areas can be revegetated to control erosion. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing roads.

This unit is moderately suited to recreational development. The main limitations are the shallow soil depth, steepness of slope, and droughtiness. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level slopes. Soil material can be stockpiled and used to reclaim the area.

This map unit is in capability subclass IVe.

12—Chinen clay loam, 15 to 30 percent slopes. This shallow, well drained soil is on tilted and dissected limestone plateaus on the islands of Saipan, Tinian, and Rota. It formed in sediment over porous coralline limestone. Slopes are long and plane. The vegetation is mainly secondary forest. Some areas are under grasses and forbs. Elevation is 10 to 450 meters.

Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick. The subsoil is dark brown clay about 12 centimeters thick over yellowish red clay loam about 17 centimeters thick. Jagged, irregular limestone is at a depth of 35 centimeters. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Included in this unit are small areas of Rock outcrop; Saipan, Dandan, and Takpochao soils; soils that have short, steep slopes; vertical cliffs; soils that have a clay subsoil; and soils that have limestone at a depth of less than 25 centimeters or more that 50 centimeters. Also included on Saipan and Tinian are areas of soils that were disturbed during World War II. These areas are characterized by bulldozed areas, areas of limestone gravel fill, and piles of concrete and rubble. On Rota, there are small areas of Luta soils and areas of very sticky clay soils. Included areas make up about 20 percent of the total hectarage.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is severe.

This unit is used as watershed and wildlife habitat and for grazing. It can be used for subsistence farming

and for homesite and urban development.

This unit is unsuited to commercial farming. It is limited by the steepness of slope and severe hazard of erosion.

This unit is poorly suited to subsistence farming. It is limited mainly by the severe hazard of erosion, shallow soil depth, and droughtiness. Clean cultivation should be avoided. Fruit trees and banana plants can be grown in the included scattered pockets of moderately deep soils. The limestone can be excavated to widen these pockets. Irrigation is necessary during the dry season.

This unit is moderately suited to grazing. The main limitations are the hazard of gully erosion on livestock trails and droughtiness. Stocking rates can be adjusted to the amount of forage available. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is poorly suited to homesite and urban development. The main limitations are the steepness of slope, severe hazard of erosion, and shallow depth to bedrock. Slopes are too steep for use of conventional construction techniques. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as feasible help to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Excavation is difficult because of shallow depth to bedrock. Before constructing buildings or roads, gravel fill can be spread on the site to improve the load supporting capacity of the soil. Septic tank absorption fields will not filter effluent properly. This effluent can contaminate the ground water.

This unit is poorly suited to recreational development. The main limitation is slope, which restricts the recreational use of this unit to a few paths and trails.

This map unit is in capability subclass VIe.

13—Chinen very gravelly sandy loam, 0 to 5 percent slopes. This moderately deep, well drained soil is on limestone plateaus on the islands of Saipan and Tinian. It formed in fill material that was spread over the natural soil surface during World War II. Slopes are long and plane. The vegetation is mainly secondary forest. Some areas are under grasses and forbs. Elevation is 10 to 450 meters.

Typically, the surface layer is very gravelly sandy loam fill material about 25 centimeters thick. Below this is a buried surface layer that is very dark grayish brown and dark brown clay loam and clay to a depth of 43 centimeters. The subsoil to a depth of 60 centimeters is yellowish red clay loam over jagged, irregular limestone. Depth to porous coralline limestone is dominantly 50 to 100 centimeters.

Included in this unit are bunkers, piles of concrete and rubble, gravel pads more than 25 centimeters thick, bulldozed areas, and other areas disturbed during World War II. Also included are small areas of Chinen, Dandan, and Saipan soils that have little if any fill material and small areas of Rock outcrop. Included areas make up about 20 percent of the total hectarage.

Permeability of this Chinen soil is moderate. Effective rooting depth is 30 to 100 centimeters. Available water capacity is moderate. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for grazing, homesite development, watershed, and wildlife habitat. It can be used for recreational development and subsistence or commercial farming.

This unit is poorly suited to commercial crops. It is limited mainly by the very gravelly fill material, debris from World War II, and droughtiness. The very gravelly fill material must be scraped off with a bulldozer before vegetable or field crops can be grown. Irrigation is needed throughout the year for high yields of vegetables and for maximum production of field crops. Because the Chinen soil is droughty, light and frequent applications of irrigation water are needed.

The limitations for subsistence farming are similar to those for commercial farming. The very gravelly fill material must be excavated before crops can be grown. Individual holes can be dug for fruit trees or banana plants. Fruit trees and banana plants can be grown in some of the scattered pockets of moderately deep soils. The limestone can be excavated to widen these pockets. Growth and production of banana, papaya, and other fruit-bearing trees can be increased by irrigating during the dry season.

This unit is moderately suited to grazing. The main limitation is droughtiness. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion.

This unit is moderately suited to homesite and urban development. The main limitation is depth to bedrock. Excavation is difficult because of depth to bedrock. Septic tank absorption fields will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

This unit is poorly suited to recreational development. The main limitations are droughtiness and the very gravelly fill material.

This map unit is in capability subclass IIIs.

14—Chinen very gravelly sandy loam, 5 to 15 percent slopes. This moderately deep, well drained soil is on limestone plateaus on the islands of Saipan and Tinian. It formed in fill material that was spread over the natural soil surface during World War II. Slopes are long and plane. Occasional cut and fill benches are present. The vegetation is mainly secondary forest. Some areas are under grasses and forbs. Elevation is 10 to 450 meters.

Typically, the surface layer is very gravelly sandy loam fill material about 20 centimeters thick. Below this is a buried surface layer that is very dark grayish brown and dark brown clay loam and clay to a depth of 43 centimeters. The subsoil to a depth of 60 centimeters is yellowish red clay loam over jagged, irregular limestone. Depth to porous coralline limestone is dominantly 50 to 100 centimeters.

Included in this unit are bunkers, piles of concrete and rubble, gravel pads more than 20 centimeters thick, bulldozed areas, and other areas disturbed during World War II; pinnacles of limestone are at the base of the fill material. Also included are small areas of Chinen, Dandan, and Saipan soils that have little if any fill material, areas of Rock outcrop, and nearly level soils. Included areas make up about 20 percent of the total hectarage.

Permeability of this Chinen soil is moderate. Effective rooting depth is 50 to 100 centimeters. Available water capacity is moderate. Runoff is medium, and the hazard of water erosion is slight.

This unit is used for grazing, homesite development, watershed, and wildlife habitat. It can be used for recreational development and subsistence or commercial farming.

This unit is poorly suited to commercial crops. It is limited mainly by the very gravelly fill material, the hazard of erosion, debris from World War II, soil depth, and droughtiness. The very gravelly fill material must be scraped off with a bulldozer before vegetable or field crops can be grown. An erosion control system that can include diversions, terraces, hillside ditches, and grassed waterways may be needed. Because the Chinen soil is droughty, light and frequent applications of irrigation water are needed.

The limitations for subsistence farming are similar to those for commercial farming. The very gravelly fill material must be excavated before crops can be grown. Individual holes can be dug for fruit trees or banana plants. Fruit trees and banana plants can be grown in the scattered included pockets of moderately deep soils. The limestone can be excavated to widen these pockets. Growth and production of banana, papaya, and other fruit-bearing plants can be increased by irrigating during the dry season.

This unit is moderately suited to grazing. The main limitation is droughtiness. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion.

This unit is moderately suited to homesite and urban development. The main limitations are the steepness of slope and depth to bedrock. Excavation is difficult because of depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high.

This unit is poorly suited to recreational development. The main limitations are droughtiness and the very gravelly fill material.

This map unit is in capability subclass IVs.

15—Chinen-Rock outcrop complex, 3 to 15 percent slopes. This map unit is on limestone plateaus on the islands of Saipan, Tinian, and Aguijan. Slopes are long and plane. The vegetation is mainly native forest. Elevation is 10 to 450 meters.

This unit is 50 percent Chinen clay loam and 30 percent limestone Rock outcrop. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are about 10 percent Takpochao soils. Also included are small areas of Dandan and Saipan soils, soils that have steep slopes, steep escarpments, soils that are less that 25 centimeters or more that 50 centimeters deep to limestone, and nearly level soils. Some areas were disturbed during World War II. These areas are characterized by bulldozed areas, areas of limestone gravel fill, and piles of concrete and other rubble. Included areas make up about 20 percent of the total hectarage.

The Chinen soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick. The subsoil is dark brown clay about 12 centimeters thick over yellowish red clay loam about 17 centimeters thick. Jagged, irregular limestone is at a depth of 35 centimeters. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is moderate.

The Rock outcrop is white, porous coralline limestone. The surface is jagged and irregular. Organic debris, soil material, and roots are in cracks and interstices. Runoff is rapid.

This unit is used for grazing, homesite development, watershed, and wildlife habitat. It can be used for subsistence farming and recreation.

This unit is unsuited to commercial farming. It is limited by the areas of Rock outcrop. The unit is poorly suited to subsistence farming. It is limited mainly by the areas of Rock outcrop, shallow soil depth, droughtiness, and the hazard of erosion. Crops can be planted only at irregular intervals between the areas of Rock outcrop. Vehicle access and mechanical tillage are restricted by the areas of Rock outcrop. Fruit trees and banana plants can be grown in the scattered included pockets of moderately deep soils. The limestone can be excavated to widen these pockets. Clean cultivation should be avoided where feasible. Irrigation is necessary during the dry season.

This unit is poorly suited to grazing. The main limitations are the areas of Rock outcrop and droughtiness. The areas of Rock outcrop limit the pasture management practices that can be used. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion.

This unit is poorly suited to homesite and urban development. The main limitations are the areas of Rock outcrop, depth to bedrock, steepness of slope, and moderate hazard of erosion. Excavation is difficult because of depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high.

This unit is poorly suited to recreational development. The areas of Rock outcrop limit use of this unit to a few paths and trails.

The Chinen soil is in capability subclass IVe, and Rock outcrop is in capability subclass VIIIs.

16—Chinen-Rock outcrop complex, 15 to 30 percent slopes. This map unit is on limestone plateaus and escarpments on the islands of Saipan and Tinian. Slopes are long and plane. The vegetation is mainly native forest. Elevation is 10 to 450 meters.

This unit is 50 percent Chinen clay loam and 30 percent limestone Rock outcrop. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit is about 15 percent Takpochao soils. Also included are small areas of Dandan soils, vertical cliffs, soils that are less than 25 centimeters or more than 50 centimeters deep to limestone, and nearly level to strongly sloping soils. Included areas make up about 20 percent of the total hectarage.

The Chinen soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick. The subsoil is dark brown clay about 12 centimeters thick over yellowish red clay loam about 17 centimeters thick. Jagged, irregular limestone is at a depth of 35 centimeters. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is severe.

The Rock outcrop is white, porous coralline limestone. The surface is jagged and irregular. Organic debris, soil material, and roots are in cracks and interstices. Runoff is very rapid.

This unit is used as watershed and wildlife habitat. It can be used for grazing, subsistence farming, and recreational development.

This unit is unsuited to commercial farming or homesite development. It is limited by the areas of Rock outcrop and steepness of slope.

This unit is poorly suited to subsistence farming. It is limited mainly by the areas of Rock outcrop, shallow soil depth, droughtiness, and severe hazard of erosion. Crops can be planted only at irregular intervals between the areas of Rock outcrop. Vehicle access and mechanical tillage are restricted by the areas of Rock outcrop. Fruit trees and banana plants can be grown in the scattered included pockets of moderately deep soils. The limestone can be excavated to widen these pockets. Clean cultivation should be avoided where feasible. Irrigation is necessary during the dry season.

This unit is poorly suited to grazing. The main limitations are the areas of Rock outcrop, hazard of gully erosion on livestock trails, and droughtiness. The areas of Rock outcrop limit the pasture management practices that can be used. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion. Most areas of this unit are heavily forested and forage production is very low.

This unit is poorly suited to recreational development. The main limitations are the areas of Rock outcrop and steepness of slope. These areas limit the recreational use of this unit to a few paths and trails.

The Chinen soil is in capability subclass VIe, and Rock outcrop is in capability subclass VIIIs.

17—Chinen-Urban land complex, 0 to 5 percent slopes. This map unit is on limestone plateaus, mainly around airstrips on the islands of Saipan, Tinian, and Aguijan. Slopes are long and plane. The vegetation on the Chinen soil is mainly grasses and forbs and some secondary forest. The Urban land is barren. Elevation is 10 to 160 meters.

This unit is 50 percent Chinen clay loam and 30 percent Urban land. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit is about 15 percent Chinen very gravelly sandy loam. Also included are small areas of Saipan and Dandan soils, Chinen soils that have been bulldozed and disturbed, Shioya soils near the coast, and soils that are less than 25 centimeters or more than 50 centimeters deep to limestone. Included areas make up about 20 percent of the total hectarage.

The Chinen soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick. The subsoil is dark brown clay about 12 centimeters thick over yellowish red clay loam about 17 centimeters thick. Jagged, irregular limestone is at a depth of 35 centimeters. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Runoff is slow, and the hazard of water erosion is slight.

Urban land consists of paved and impervious areas, such as airstrips, roads, buildings, and parking lots. These areas have a base of limestone gravel fill. The only vegetation is a few pioneer species that root along fractures in the pavement. Runoff is very rapid.

This unit is used for homesite and urban development, wildlife habitat, and watershed. It can be used for grazing, subsistence farming, and recreational development.

This unit is unsuited to commercial farming.

This unit is poorly suited to subsistence farming. It is limited mainly by the soil depth, droughtiness, and presence of Urban land and other disturbed areas. Only the Chinen soil can be farmed. Fruit trees and banana plants can be grown in the scattered included pockets of moderately deep soils. The limestone can be excavated to widen these pockets. Irrigation is necessary during the dry season.

This unit is moderately suited to grazing. The main limitations are droughtiness and the areas of Urban land. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion.

This unit is moderately suited to homesite and urban development. The main limitations are the depth to bedrock and the low strength of the Chinen soil. The presence of abandoned airstrips in some areas affects the planning and development of homesites and commercial buildings. Excavation is difficult because of the depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. The bearing capacity of the Chinen soil can be improved by spreading gravel fill on the site before constructing buildings and roads.

This unit is moderately suited to recreational development. It is limited by the areas of Urban land, shallow soil depth, and droughtiness. Urban land cannot be vegetated and is unsuitable for recreational development.

The Chinen soil is in capability subclass IIIs. Urban land is not assigned a capability classification.

18—Chinen-Urban land complex, 5 to 15 percent slopes. This map unit is on high, rolling limestone plateaus on the island of Saipan. Slopes are short and undulating. The vegetation is mainly lawn grasses and forbs on the Chinen soils. The Urban land is barren. Elevation is 10 to 250 meters.

This unit is 55 percent Chinen clay loam and 25 percent Urban land. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit is about 15 percent Chinen very gravelly soils and soils that are less than 25 centimeters or more than 50 centimeters deep to limestone. Also included are small areas of Saipan and Dandan soils, limestone Rock outcrop, and Chinen soils that have been bulldozed and disturbed during construction. Included areas make up about 20 percent of the total hectarage.

The Chinen soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick. The subsoil is dark brown clay about 12 centimeters thick over yellowish red clay loam about 17 centimeters thick. Jagged, irregular limestone is at a depth of 35 centimeters. The depth to porous coralline limestone generally

ranges from 25 to 50 centimeters.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is moderate.

Urban land consists of paved and impervious surfaces such as buildings, roads, and parking lots. These areas have a base of limestone gravel fill. The only vegetation is a few pioneer species that root along fractures in the pavement. Runoff is very rapid.

This unit is used for homesite and urban development and as watershed. It can be used for recreational development and subsistence farming.

This unit is poorly suited to subsistence farming. Only the Chinen soil in this unit is suited to crops. This soil is limited mainly by shallow depth, droughtiness, moderate hazard of erosion, and the presence of Urban land. Fruit trees and banana plants can be grown in the scattered included pockets of moderately deep soils. The limestone can be excavated to widen these pockets. Irrigation is necessary during the dry season.

This unit is moderately suited to homesite and urban development. The main limitations are the depth to bedrock, steepness of slope, and moderate hazard of erosion. Excavation is difficult because of the depth to bedrock. Before constructing buildings or roads, gravel fill can be spread on the site to improve the load supporting capacity of the soil. The underlying limestone will not filter effluent properly from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. Preserving the existing plant cover during construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as feasible helps to control erosion.

This unit is moderately suited to recreational development. It is limited by the areas of Urban land, shallow soil depth, steepness of slope, and droughtiness. Urban land cannot be vegetated and is unsuitable for most recreational development. Cuts and fills are needed to establish playgrounds, ball fields, and other areas that require extensive level slopes.

The Chinen soil is in capability subclass IVe. Urban land is not assigned a capability classification.

19—Dandan-Chinen complex, 0 to 5 percent slopes. This map unit is on limestone plateaus on the island of Tinian. Slopes are long and undulating. The vegetation is mainly secondary forest. Some areas are in pasture grasses. Elevation is 10 to 150 meters.

This unit is 50 percent Dandan clay loam and 40 percent Chinen clay loam (fig. 5). The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Saipan soils and areas where the surface layer was removed during clearing. Also included are small areas of soils that have short, steep slopes and soils that were disturbed during World War II and are characterized by bulldozed areas, limestone gravel fill, and piles of concrete and other rubble. Included areas make up about 10 percent of the total hectarage.

The Dandan soil is moderately deep and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark brown clay loam about 2 centimeters thick over dark brown clay about 10 centimeters thick. The subsoil is dark reddish brown clay 54 centimeters thick. Coralline limestone is at a depth of 66 centimeters. Depth to limestone is dominantly 50 to 100 centimeters.

Permeability of the Dandan soil is moderate. Effective rooting depth is 50 to 100 centimeters. Available water capacity is moderate. Runoff is slow, and the hazard of erosion is slight.

The Chinen soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick over dark brown clay about 12 centimeters thick. The subsoil is yellowish red clay about 17 centimeters thick. Jagged, irregular limestone is at a depth of 35 centimeters. Depth to porous limestone is dominantly 25 to 50 centimeters.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for grazing, commercial and subsistence farming, homesite development, watershed, and wildlife habitat. It can be used for recreational development.

This unit is moderately suited to commercial vegetable and field crop production and is poorly suited to fruit production. It is limited mainly by the shallow depth and droughtiness of the Chinen soil. Irrigation is needed throughout the year for high yields of vegetables and for maximum production of field crops. Even during the rainy season, short dry periods will stress vegetable crops on the Chinen soil unless they are irrigated. Because the Chinen soil is droughty, light and frequent applications of irrigation water are needed. All tillage should be across the slope.

The limitations for subsistence farming are similar to

Figure 5.—Typical area of moderately deep Dandan clay loam and shallow Chinen clay loam.

those for commercial farming. Fruit trees and banana plants can be grown on the Dandan soil.

This unit is well suited to grazing. The main limitation is the droughtiness of the Chinen soil. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion.

This unit is moderately suited to homesite and urban development. The main limitations are the low soil strength, depth to bedrock, and droughtiness of the

Chinen soil. Excavation is difficult because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing roads.

This unit is moderately suited to recreational development. The main limitations are the shallow soil depth and droughtiness of the Chinen soil and low soil strength.

This map unit is in capability subclass IIIs.

20—Dandan-Chinen complex, 5 to 15 percent slopes. This map unit is on undulating limestone plateaus on the islands of Tinian, Rota, and Aguijan. Slopes are long and undulating. The vegetation is mainly secondary forest. Some areas are in pasture grasses. Elevation is 10 to 450 meters.

This unit is 50 percent Dandan clay and 40 percent Chinen clay. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Saipan soils and limestone Rock outcrop in places where the surface layer has been removed. Also included are small areas of soils that have short, steep slopes or are nearly level. On Tinian there are soils that were disturbed during World War II and are characterized by bulldozed areas, limestone gravel fill, and piles of concrete and other rubble. Included areas make up about 10 percent of the total hectarage.

The Dandan soil is moderately deep and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark brown clay loam about 2 centimeters thick over dark brown clay about 10 centimeters thick. The subsoil is dark reddish brown clay 44 centimeterss thick over limestone. Depth to porous coralline limestone is dominantly 50 to 100 centimeters.

Permeability of the Dandan soil is moderate. Effective rooting depth is 50 to 100 centimeters. Available water capacity is moderate. Runoff is medium, and the hazard of water erosion is moderate.

The Chinen soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick. The subsoil to a depth of 18 centimeters is dark brown clay over yellowish red clay. Limestone is at a depth of 18 centimeters. Depth to limestone is dominantly 25 to 50 centimeters.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used for grazing, commercial and subsistence farming, homesite development, watershed, and wildlife habitat. It can be used for recreational development.

This unit is moderately suited to commercial vegetable and field crop production and is poorly suited to fruit production. It is limited mainly by the moderate hazard of erosion and by the shallow depth and droughtiness of the Chinen soil. If orchards or banana plantations are established on this unit, some plants will be located on the Chinen soil. Yields will be lower for these plants, and the hazard of windthrow will be greater. Irrigation is necessary during the dry season for vegetables and for maximum production of field crops. Even during the rainy season, short dry periods will stress vegetable crops on the Chinen soil unless they are irrigated. Because the Chinen soil is droughty, light and frequent applications of irrigation water are needed. All tillage should be across the slope. An erosion control system is needed. This system can include diversions, terraces, hillside ditches, and grassed waterways.

The limitations for subsistence farming are similar to those for commercial farming. Fruit trees and banana plants can be grown on the moderately deep Dandan soil. Clean cultivation should be avoided.

This unit is well suited to grazing. The main limitations are the droughtiness of the Chinen soil and the hazard of erosion of livestock trails. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion.

This unit is moderately suited to homesite and urban development. The main limitations are slope and the low soil strength and shallow depth to bedrock in the Chinen soil. Excavation is difficult because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. The effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing roads.

This unit is moderately suited to recreational development. The main limitations are the shallow

depth and droughtiness of the Chinen soil, slope, and low soil strength. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level slopes.

The Dandan soil is in capability subclass IIIe, and the Chinen is in capability subclass IVe.

21—Dandan-Chinen-Pits complex, 0 to 5 percent slopes. This map unit is on limestone plateaus around World War II bunker areas on the island of Tinian. Slopes are long and plane and are broken by the steep-sided pits. The vegetation is mainly secondary forest. Elevation is 10 to 50 meters.

This unit is 30 percent Dandan clay, 30 percent Chinen clay, and 30 percent Pits. The Pits occur as rectangular excavations about 25 meters by 50 meters in size and are uniformly spaced at 100 to 200 meters. The Dandan and Chinen soils are in the undisturbed areas between the excavations and are not in a predictable pattern.

Included in this unit are small areas of Saipan soils, limestone Rock outcrop, and bulldozed areas where the surface layer has been removed from the Dandan and Chinen soils. Also included are small areas of soils that were disturbed during World War II and are characterized by limestone gravel fill and piles of concrete and other rubble. Included areas make up about 10 percent of the total hectarage.

The Dandan soil is moderately deep and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark brown clay loam about 2 centimeters thick over dark brown clay about 10 centimeters thick. The subsoil is reddish brown clay 44 centimeters thick over limestone. Depth to porous coralline limestone is dominantly 50 to 100 centimeters.

Permeability of the Dandan soil is moderate. Effective rooting depth is 50 to 100 centimeters. Available water capacity is moderate. Runoff is slow, and the hazard of water erosion is slight.

The Chinen soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark grayish brown clay loam about 6 centimeters thick. The subsoil to a depth of 35 centimeters is dark brown clay over yellowish red clay loam. Porous coralline limestone is at a depth of 35 centimeters. Depth to limestone is dominantly 25 to 50 centimeters.

Permeability of the Chinen soil is moderate. Effective rooting depth is 25 to 50 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

Pits are excavations made for bunkers during World War II. They consist of a short, steep outer slope; a narrow berm; and a longer, steep inner slope with a level interior floor 2 or 3 meters below the surrounding undisturbed soil surface. The soil material in these areas consists of limestone cobbles and stones, concrete fragments of various sizes, and metal artifacts.

This unit is used for grazing, wildlife habitat, and watershed. It can be used for subsistence farming and for homesite and recreational development.

This unit is unsuited to commercial crops. It is limited by the areas of Pits.

This unit is poorly suited to subsistence farming. It is limited mainly by the areas of Pits, which are unsuitable for farming. Crops can be grown in undisturbed areas of the Chinen and Dandan soils. Undisturbed areas are limited by the shallow depth and droughtiness of the Chinen soil. Fruit trees and banana plants can be grown on the Dandan soil. Irrigation is necessary on the Chinen soil.

This unit is moderately suited to grazing. The main limitation is the areas of Pits, which are unsuitable for grazing. Undisturbed areas of Chinen and Dandan soils are well suited. These areas are limited by the droughtiness of the Chinen soil and by gully erosion on livestock trails. Stocking rates should be adjusted to the amount of forage available. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is moderately suited to homesite and urban development. The main limitations are the areas of Pits, shallow depth to bedrock in the Chinen soil, steepness of slope, moderate hazard of erosion, and low soil strength. The areas of Pits can be leveled and smoothed with heavy equipment. Excavation is difficult in areas of the Chinen soil because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. The effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. The bearing capacity of the Chinen and Dandan soils is improved by spreading gravel fill on the site before constructing roads.

This unit is moderately suited to recreational development. The main limitations are the areas of Pits, shallow soil depth and droughtiness of the Chinen soil, slope, and low soil strength. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level slopes.

The Dandan and Chinen soils are in capability subclass IIIs, and Pits are in capability subclass VIIIs.

22—Dandan-Chinen-Pits complex, 5 to 15 percent slopes. This map unit is on limestone plateaus around World War II bunker areas on the island of Tinian. Slopes are long and plane and are broken by steep-sided pits. The vegetation is mainly secondary forest. Elevation is 10 to 80 meters.

This unit is 30 percent Dandan clay, 30 percent Chinen clay, and 30 percent Pits. The Pits occur as rectangular excavations about 25 meters by 50 meters in size and uniformly spaced at 100 to 200 meters. The Dandan and Chinen soils are in the undisturbed areas between the excavations and are not in a predictable pattern.

Included in this unit are small areas of Saipan soils, areas of Rock outcrop, and bulldozed areas where the surface layer has been removed from the Dandan and Chinen soils. Also included are small areas of soils that were disturbed during World War II and are characterized by limestone gravel fill and piles of concrete and other rubble. Included areas make up about 10 percent of the total hectarage.

The Dandan soil is moderately deep and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark brown clay loam about 2 centimeters thick over brown clay about 10 centimeters thick. The subsoil is reddish brown clay 44 centimeters thick over limestone. Depth to limestone is dominantly 50 to 100 centimeters.

Permeability of the Dandan soil is moderate. Available water capacity is moderate. Effective rooting depth is 50 to 100 centimeters. Runoff is medium, and the hazard of water erosion is moderate.

The Chinen soil is shallow and well drained. It formed in sediment over porous coralline limestone. The surface layer is very dark grayish brown clay loam about 6 centimeters thick over dark brown clay about 12 centimeters thick. The subsoil is yellowish red clay about 17 centimeters thick over limestone. Depth to porous coralline limestone is dominantly 25 to 50 centimeters.

Permeability of the Chinen soil is moderate. Available water capacity is low. Effective rooting depth is 25 to 50 centimeters. Runoff is medium, and the hazard of erosion is moderate.

Pits are excavations made for bunkers during World War II. They consist of a short, steep outer slope; a narrow berm; and a longer, steep inner slope with a level interior floor 2 or 3 meters below the surrounding undisturbed soil surface. The soil material in these areas consists of limestone cobbles and stones, concrete fragments of various sizes, and metal artifacts.

This unit is used for grazing, wildlife habitat, and watershed. It can be used for subsistence farming and for homesite and recreational development.

This unit is not suited to commercial farming. It is limited by the areas of Pits.

This unit is poorly suited to subsistence farming. Only the Dandan and Chinen soils are suited to crops. The unit is limited mainly by the shallow depth and droughtiness of the Chinen soil, moderate hazard of erosion, and presence of abandoned bunkers and other disturbed areas. Fruit trees and banana plants can be grown on the moderately deep Dandan soil. Clean cultivation should be avoided. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit-bearing plants can be increased by irrigating during the dry season.

This unit is moderately suited to grazing. The main limitation is the areas of Pits, which are unsuitable for grazing. Undisturbed areas of the Chinen and Dandan soils are well suited. These areas are limited by the droughtiness of the Chinen soil and by gully erosion on livestock trails. Stocking rates should be adjusted to the amount of forage available. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is poorly suited to homesite and urban development. The main limitations are the presence of abandoned bunkers, steepness of slope, shallow depth to bedrock in the Chinen soil, and low strength of the Chinen and Dandan soils. The bunkers can be leveled and smoothed with heavy equipment. Excavation is difficult because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. The effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. Preserving the existing plant cover during construction helps to control erosion. The bearing capacity of the Chinen and Dandan soils is improved by spreading gravel fill on the site before constructing roads.

This unit is poorly suited to recreational development. The main limitations are the areas of Pits, shallow depth and droughtiness of the Chinen soil, slope, and low soil strength. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level areas.

The Chinen soil is in capability subclass IVe, the Dandan soil is in capability subclass IIIe, and Pits is in capability subclass VIIIs.

23—Dandan-Saipan clays, 0 to 5 percent slopes. This map unit is on limestone plateaus on the island of Tinian. Slopes are long and undulating. The vegetation is mainly secondary forest. Elevation is 10 to 150 meters.

This unit is 50 percent Dandan clay and 35 percent Saipan clay. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Chinen and Akina soils. Also included are small areas of soils that were disturbed during World War II and are characterized by bulldozed areas, limestone gravel fill, and piles of concrete and other rubble. Included areas make up about 15 percent of the total hectarage.

The Dandan soil is moderately deep and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark brown clay loam about 2 centimeters thick over dark brown clay about 10 centimeters thick. The subsoil is reddish brown clay 44 centimeters thick over limestone. Depth to porous limestone is dominantly 50 to 100 centimeters.

Permeability of the Dandan soil is moderate. Effective rooting depth is 50 to 100 centimeters. Runoff is slow, and the hazard of water erosion is slight.

The Saipan soil is deep and well drained. It formed in sediment overlying coralline limestone. The surface layer is dark brown clay about 9 centimeters thick over dark reddish brown clay about 7 centimeters thick. The subsoil to a depth of 120 centimeters is reddish brown and yellowish red silty clay and clay over limestone. Depth to limestone is more than 100 centimeters.

Permeability of the Saipan soil is moderate. Effective rooting depth is more than 100 centimeters. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for grazing, commercial and subsistence farming, watershed, and wildlife habitat. It can be used for homesite and recreational development.

This unit is well suited to commercial and subsistence farming and to grazing.

This unit is moderately suited to homesite and urban development. The main limitation is low soil strength. The bearing capacity is improved by spreading gravel fill on the site before constructing roads.

This unit is well suited to recreational development. The main limitation is low soil strength.

This map unit is in capability subclass IIs.

24—Dandan-Saipan clays, 5 to 15 percent slopes. This map unit is on rolling limestone plateaus on the island of Tinian. Slopes are long and undulating. The vegetation is mainly secondary forest. Elevation is 10 to 150 meters.

This unit is 50 percent Dandan clay and 35 percent Saipan clay. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Chinen soils and nearly level Saipan and Dandan soils. Also included are small areas of soils that were disturbed during World War II and are characterized by bulldozed areas, limestone gravel fill, and piles of concrete and other rubble. Included areas make up about 15 percent of the total hectarage.

The Dandan soil is moderately deep and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is very dark brown clay loam about 2 centimeters thick over dark brown clay about 10 centimeters thick. The subsoil is reddish brown clay about 44 centimeterss thick over limestone. Depth to coralline limestone is dominantly 50 to 100 centimeters.

Permeability of the Dandan soil is moderate. Available water capacity is moderate. Effective rooting depth is 50 to 100 centimeters. Runoff is medium, and the hazard of water erosion is moderate.

The Saipan soil is deep and well drained. It formed in sediment overlying coralline limestone. The surface layer is dark brown clay about 9 centimeters thick over dark reddish brown clay about 7 centimeters thick. The subsoil to a depth of 120 centimeters is reddish brown and yellowish red silty clay and clay over limestone. Depth to limestone is more than 100 centimeters.

Permeability of the Saipan soil is moderate. Available water capacity is moderate. Effective rooting depth is more than 100 centimeters. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used for grazing, commercial and subsistence farming, watershed, and wildlife habitat. It can be used for homesite and recreational development.

This unit is moderately suited to commercial farming. It is limited mainly by the moderate hazard of erosion. All tillage should be across the slope. An erosion control system that can include diversions, terraces, hillside ditches, and grassed waterways may be needed.

The limitations for subsistence farming are similar to those for commercial farming. Clean cultivation should be avoided.

This unit is well suited to grazing. The main limitation is the hazard of gully erosion on livestock trails. Using

cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion.

This unit is moderately suited to homesite and urban development. The main limitations are the steepness of slope, moderate hazard of erosion, and low soil strength. Preserving the existing plant cover during construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as feasible helps to control erosion. Before constructing buildings or roads, gravel fill can be spread on the site to improve the load supporting capacity of the soil.

This unit is moderately suited to recreational development. The main limitations are steepness of slope and low soil strength. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level areas.

This map unit is in capability subclass IIIe.

25—Inarajan clay, 0 to 5 percent slopes. This very deep, somewhat poorly drained soil is on foot slopes and in depressional areas on the islands of Saipan and Tinian. It formed in mixed alluvium from volcanic and limestone uplands. Slopes are long and plane. The vegetation is water-tolerant grasses and forbs in some places and secondary forest in other places. Elevation is 0 to 100 meters.

Typically, the surface layer is black clay about 18 centimeters thick over mixed very dark gray and very dark grayish brown clay that has many fine distinct mottles of dark grayish brown and reddish brown and is 22 centimeters thick. The substratum to a depth of 150 centimeters is brown, yellowish brown, and dark yellowish brown clay that has prominent gray mottles.

Included in this unit are small areas of Saipan, Kagman, and Chinen soils, mostly on the upland edges of the unit. Also included are small areas of Inarajan soils in level, low-lying areas; soils adjacent to the uplands that have slopes of as much as 10 percent and are somewhat poorly drained to moderately well drained; and soils that were disturbed during World War II and contain limestone gravel fill, fragments of concrete, metal artifacts, and other debris.

Permeability of this Inarajan soil is slow. Rooting depth is more than 150 centimeters for water-tolerant plants but is only 30 to 100 centimeters for perennial plants that are sensitive to wetness. Available water capacity is high. Runoff is slow, and the hazard of water erosion is slight. There is a seasonal high water table that fluctuates between depths of 30 and 100 centimeters during the rainy season. Low-lying, nearly level areas commonly are ponded following heavy rainstorms.

This unit is used for homesite development, subsistence and commercial farming, grazing, watershed, and wildlife habitat. It can be used for recreational development if flooding is controlled.

This unit is moderately suited to commercial and subsistence farming, poorly suited to fruit trees, and well suited to aquaculture and crops that tolerate wetness, such as taro. The main limitations are the high water table, occasional flooding during the rainy season, and hazard of compaction when the soil is moist. Using raised beds for crops helps to overcome the problem of wetness. Diversion ditches or subsurface drainage systems can be used to remove excess water if a suitable outlet is available. Field operations should be avoided after heavy rains.

This unit is moderately suited to grazing. The main limitation is the hazard of compaction. Livestock should be removed when the soil is ponded.

This unit is poorly suited to homesite and urban development. It is limited by wetness and a hazard of flooding during the rainy season and by low soil strength. Drainage is needed if roads and building foundations are constructed. Foundation drains and proper grading will prevent many wetness problems for new homes. Diversion ditches can be used to protect urban areas. Septic tank absorption fields will not function properly because of the seasonal high water table and the slow permeability. Before constructing buildings or roads, gravel fill can be spread on the site to improve the bearing capacity of the soil.

This unit is poorly suited to recreational development. The main limitations are seasonal wetness and flooding and low soil strength. Facilities should be protected from flooding. Compaction adversely affects turf grasses. Drainage should be provided for paths and trails. This unit is well suited to the development of ponds for recreational use.

This map unit is in capability subclass IIIw.

26—Kagman clay, 0 to 5 percent slopes. This very deep, well drained soil is on limestone plateaus on the islands of Saipan and Tinian. It formed in sediment over coralline limestone. Slopes are long and plane. The vegetation is mainly secondary forest. Elevation is 3 to 240 meters.

Typically, the surface layer is very dark grayish brown and dark brown clay about 15 centimeters thick.

The subsoil to a depth of 150 centimeters is strong brown clay. Depth to limestone is more than 150 centimeters.

Included in this unit are small areas of Chacha, Saipan, and Chinen soils, areas of Rock outcrop on toe slopes, and soils that are moderately deep to limestone. Also included are small areas of strongly sloping Kagman soils and areas that were disturbed during World War II and are characterized by bulldozed areas, limestone gravel fill, and piles of concrete and other rubble. Included areas make up about 20 percent of the total hectarage.

Permeability of this Kagman soil is moderately slow. Effective rooting depth is more than 150 centimeters. Available water capacity is high. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for commercial and subsistence farming, grazing, homesite and recreational development, watershed, and wildlife habitat.

This unit is well suited to commercial and subsistence farming. It is limited mainly by wetness during the rainy season and a hazard of compaction when the soil is moist. Because of the clay texture of the soil, field access is not feasible during much of the rainy season. Crops that require frequent maintenance are poorly suited to rainy season production. Using raised beds for crops helps to overcome the problem of wetness. Ditches can be used to remove excess water during periods of heavy rain if a suitable outlet is available. To prevent soil compaction, field operations should be avoided immediately after heavy rains.

This unit is well suited to grazing. The main limitation is the hazard of soil compaction when the soil is moist. During the rainy season, access for grass management is difficult.

This unit is moderately suited to homesite and urban development. The main limitations are low soil strength and wetness during the rainy season. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing buildings and roads. Drainage ditches may be needed to remove excess water during heavy rainfall. Septic tank absorption fields must be large enough to overcome the limitation of slow permeability.

This unit is moderately suited to recreational development. The main limitations are low soil strength and a hazard of compaction. Compaction adversely affects turf grasses.

This map unit is in capability subclass IIs.

27—Kagman clay, 5 to 15 percent slopes. This very deep, well drained soil is on limestone plateaus on the islands of Saipan and Tinian. It formed in sediment over coralline limestone. Slopes are long and undulating. The vegetation is mainly secondary forest. Elevation is 3 to 240 meters.

The surface layer is very dark grayish brown and dark brown clay about 15 centimeters thick. The subsoil to a depth of more than 150 centimeters is strong brown clay. Depth to limestone is more than 150 centimeters.

Included in this unit are small areas of Chacha, Saipan, and Chinen soils, areas of Rock outcrop on toe slopes, and soils that are moderately deep to limestone. Also included are small areas of nearly level and moderately steep Kagman soils and areas that were disturbed during World War II and are characterized by bulldozed areas, limestone gravel fill, and piles of concrete and other rubble. Included areas make up about 20 percent of the total hectarage.

Permeability of the Kagman soil is moderately slow. Effective rooting depth is more than 150 centimeters. Available water capacity is high. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used for commercial and subsistence farming, grazing, homesite and recreational development, watershed, and wildlife habitat.

This unit is moderately suited to commercial farming. It is limited mainly by the moderate hazard of erosion and the hazard of compaction when the soil is moist during the rainy season. Because of the clay texture, field access is not feasible during much of the rainy season. Crops that require frequent maintenance are difficult to grow during the rainy season. Using raised beds for crops helps to overcome the problem of wetness. Ditches can be used to remove excess water during the rainy season if a suitable outlet is available. All tillage should be across the slope. An erosion control system that includes diversions, terraces, hillside ditches, and grassed waterways may be needed. To prevent soil compaction, field operations should be avoided immediately after heavy rains.

The limitations for subsistence farming are similar to those for commercial farming. Clean cultivation should be avoided.

This unit is well suited to grazing. The main limitations are the hazard of soil compaction and the hazard of gully erosion on livestock trails. During the rainy season, the clay texture of the soil makes access for range management difficult. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is moderately suited to homesite and urban development. The main limitations are slope, low soil strength, and the moderate hazard of erosion. The

bearing capacity of the soil is improved by spreading gravel fill on the site before constructing buildings and roads. Drainage ditches may be needed to remove excess water. Septic tank absorption fields must be large enough to overcome the limitation of moderately slow permeability. Preserving the existing plant cover during construction helps to control erosion.

This unit is moderately suited to recreational development. The main limitations are slope, low soil strength, and the hazard of compaction. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level areas. Compaction adversely affects growth of turf grasses.

This map unit is in capability subclass IIIe.

28—Kagman very gravelly sandy loam, 0 to 5 percent slopes. This very deep, well drained soil is on limestone plateaus on the island of Saipan. It formed in fill material that was spread over the natural soil surface during World War II. Slopes are long and plane. The vegetation is mainly secondary forest. Some areas are in grasses and forbs. Elevation is 3 to 240 meters.

Typically, the surface layer is very gravelly sandy loam fill material about 20 centimeters thick over a buried surface layer of very dark grayish brown and dark brown clay that extends to a depth of 35 centimeters. The subsoil to a depth of 150 centimeters is strong brown clay. Depth to limestone is more than 150 centimeters.

Included in this unit are small areas of bunkers, piles of concrete and rubble, gravel pads more than 25 centimeters thick, bulldozed excavations, and other areas disturbed during World War II. Also included are small areas of Chinen, Kagman, and Saipan soils that have little or no fill material, soils that have short, steep slopes, and vertical cliffs along the coast. Included areas make up about 10 percent of the total hectarage.

Permeability of this Kagman soil is moderately slow. Effective rooting depth is more than 150 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for homesite development, watershed, and wildlife habitat. It can be used for grazing, recreational development, and subsistence or commercial farming.

This unit is poorly suited to commercial farming. It is limited mainly by the very gravelly fill material and debris from World War II. The very gravelly fill material must be scraped off with a bulldozer before crops can be grown. Because of the sticky clay soil, field access is not feasible during the rainy season. Crops that require frequent maintenance are difficult to grow during this season. Using raised beds for crops helps to overcome this problem. Ditches can be used to remove excess water during periods of heavy rainfall if a suitable outlet is available. To prevent soil compaction, field operations should be avoided immediately after heavy rains. All tillage should be across the slope.

The limitations for subsistence farming are similar to those for commercial farming. The very gravelly fill material must be excavated before crops can be grown. Individual holes can be dug for fruit trees and banana plants.

This unit is moderately suited to grazing. The main limitation is the presence of very gravelly fill material. Stocking rates should be adjusted to the amount of forage available.

This unit is moderately suited to homesite and urban development. Drainage ditches may be needed during periods of heavy rainfall to remove excess water. Septic tank absorption fields must be large enough to overcome the limitation of moderately slow permeability.

This unit is moderately suited to recreational development. The main limitations are droughtiness and the presence of very gravelly fill material.

This map unit is in capability subclass IVs.

29—Kagman-Urban land complex, 0 to 5 percent slopes. This map unit is on limestone plateaus in urbanized areas on the island of Saipan. Slopes are long and plane. The vegetation is mainly secondary forest. Elevation is 70 to 90 meters.

This unit is 50 percent Kagman clay and 30 percent Urban land. The components of this unit are so intricately intermingled that it was not feasible to map them separately at the scale used.

Included in this unit are areas of Kagman very gravelly sandy loam. Also included are areas of soils that are shallow or moderately deep to limestone and Kagman soils in which the upper soil layers have been mixed, removed, or otherwise disturbed during construction. Included areas make up about 20 percent of this unit.

The Kagman soil is deep and well drained. It formed in sediment over argillaceous limestone. Typically, the surface layer is very dark grayish brown and dark brown clay about 15 centimeters thick. The subsoil to a depth of 150 centimeters is strong brown clay. Depth to limestone is more than 150 centimeters.

Permeability of the Kagman soil is moderately slow. Effective rooting depth is more than 150 centimeters. Available water capacity is high. Runoff is slow, and the hazard of water erosion is slight.

Urban land consists of paved, impervious surfaces

such as roads, buildings, and parking lots. These areas have a base of limestone gravel fill.

This unit is used for homesite and urban development. It can be used for recreational development.

This unit is unsuited to commercial farming or grazing. Only the Kagman soil is suitable for farming. It is limited mainly by a hazard of compaction when the soil is moist during periods of heavy rainfall. Using raised beds for vegetables helps to overcome the limitation of wetness. Ditches can be used to remove excess water during rainy periods. Mechanical tillage and vehicle traffic should be avoided immediately after heavy rainfall.

This unit is moderately suited to homesite and urban development. The main limitation is low soil strength. Before constructing buildings and roads, gravel fill can be spread on the site to improve the load supporting capacity of the soil. Excess water can be removed by using suitably designed drainage ditches. The moderately slowly permeable Kagman soil is poorly suited to septic tank absorption fields.

The Kagman soil is moderately suited to recreational development. It is limited mainly by low soil strength and the hazard of compaction. Compaction adversely affects growth of turf grasses.

The Kagman soil is in capability subclass IIs. Urban land is not assigned a capability classification.

30—Laolao clay, 0 to 5 percent slopes. This moderately deep, well drained soil is on volcanic uplands on the island of Tinian. It formed in residuum derived dominantly from andesitic marine tuff or tuffaceous breccia. Slopes are long and undulating. The vegetation is mainly secondary forest. Elevation is sea level to 200 meters.

Typically, the surface layer is dark reddish brown clay about 15 centimeters thick. The subsoil is red clay that is underlain by strongly weathered tuffaceous material at a depth of 82 centimeters. Depth to saprolite dominantly ranges from 50 to 100 centimeters.

Included in this unit are small areas of Kagman and Saipan soils, soils that have short slopes, and areas that were disturbed during World War II. Included areas make up about 10 percent of the total hectarage.

Permeability of the Laolao soil is moderate. Effective rooting depth is 50 to 100 centimeters. Available water capacity is moderate. Runoff is slow, and the hazard of water erosion is slight.

This unit is used as watershed and wildlife habitat. It can be used for commercial and subsistence farming, grazing, and homesite and recreational development.

This unit is well suited to commercial and subsistence farming. It is limited mainly by soil acidity. Lime can be used as a soil amendment. All tillage should be across the slope.

This unit is well suited to grazing. There are few limitations.

This unit is moderately suited to homesite and urban development. The main limitation is the low soil strength. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing buildings or roads. Natural revegetation is poor on exposed subsoil material and saprolite.

This unit is moderately suited to recreational development. The main limitation is the low soil strength.

This map unit is in capability subclass IIIs.

31—Laolao clay, 5 to 15 percent slopes. This moderately deep, well drained soil is on volcanic uplands. It formed in residuum derived dominantly from volcanic tuff or tuff breccia on the islands of Saipan, Tinian, and Rota. Slopes are long and undulating. The vegetation is mainly secondary forest, although many areas are in grasses and forbs. Elevation is sea level to 200 meters.

Typically, the surface layer is dark reddish brown clay about 15 centimeters thick. The subsoil is red clay that is underlain by strongly weathered tuffaceous material at a depth of 82 centimeters. Depth to saprolite dominantly ranges from 50 to 100 centimeters.

Included in this unit are small areas of Akina, Kagman, and Saipan soils; soils that have short, steep slopes; and nearly level soils. Also included are small areas of Badland that consists of soils that have been deeply gullied, exposing saprolite. Some areas on Saipan and Tinian were disturbed during World War II. Bulldozed areas, limestone gravel fill, and piles of concrete and other rubble are in these areas. Included areas make up about 25 percent of the total hectarage.

Permeability of the Laolao soil is moderate. Effective rooting depth is 50 to 100 centimeters. Available water capacity is moderate. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used for subsistence and commercial farming, homesites, watershed, and wildlife habitat. It can be used for grazing and recreational development.

This unit is moderately suited to commercial farming. It is limited mainly by the moderate hazard of erosion and soil acidity in some areas. All tillage should be across the slope. An erosion control system is needed.

This system can include diversions, terraces, hillside ditches, and grassed waterways. Lime can be used as a soil amendment.

The limitations for subsistence farming are similar to those for commercial farming. Clean cultivation should be avoided.

This unit is well suited to grazing. The main limitation is the hazard of gully erosion on livestock trails. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is moderately suited to homesite and urban development. The main limitations are the slope, moderate hazard of erosion, and low soil strength. Preserving the existing plant cover during construction helps to control erosion. Natural revegetation is poor in areas of exposed subsoil material and saprolite. Areas disturbed during construction can be revegetated with adapted plants to control erosion. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing buildings or roads.

This unit is moderately suited to recreational development. The main limitations are slope and low soil strength. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level areas.

This map unit is in capability subclass IIIe.

32—Laolao clay, 15 to 30 percent slopes. This moderately deep, well drained soil is on volcanic uplands on the islands of Saipan and Rota. It formed in residuum derived dominantly from andesitic marine tuff or tuffaceous sandstone. Slopes are long and hilly. The vegetation is mainly secondary forest, although many areas are in grasses and forbs.

Typically, the surface layer is dark reddish brown clay about 15 centimeters thick. The subsoil is red clay that is underlain by strongly weathered tuffaceous material at a depth of about 82 centimeters. Depth to saprolite dominantly ranges from 50 to 100 centimeters.

Included in this unit are small areas of Akina and Kagman soils, soils that have an eroded surface layer, and Badland, which consists of soils that have been deeply gullied, exposing saprolite. Also included are small areas of soils that are moderately deep to impervious tuffaceous sandstone, nearly level soils on benches, and soils that have short, steep slopes. Some areas on Saipan were disturbed during World War II. Limestone gravel fill and piles of concrete and other rubble are in these areas. Included areas make up about 25 percent of the total hectarage.

Permeability of the Laolao soil is moderate. Effective rooting depth is 50 to 100 centimeters. Available water capacity is moderate. Runoff is rapid, and the hazard of water erosion is severe.

This unit is used for subsistence farming, watershed, and wildlife habitat. It can be used for grazing and for limited homesite and recreational development.

This unit is very poorly suited to commercial farming because of the steepness of slope, severe hazard of erosion, and soil acidity.

The limitations for subsistence farming are similar to those for commercial farming. Clean cultivation should be avoided.

This unit is moderately suited to grazing. The main limitation is the hazard of gully erosion on livestock trails. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is poorly suited to homesite and urban development. The main limitations are the slope, severe hazard of erosion, and low soil strength. Septic tank absorption lines should be installed on the contour. Natural revegetation is poor in areas of exposed subsoil material and saprolite. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing buildings or roads.

This unit is poorly suited to recreational development. The steepness of slope and low soil strength limit the recreational use of this unit to paths and trails.

This map unit is in capability subclass VIe.

33—Laolao clay, 30 to 60 percent slopes. This moderately deep, well drained soil is on volcanic uplands on the islands of Saipan, Tinian, and Rota. It formed in residuum derived dominantly from andesitic marine tuff or tuffaceous sandstone. Slopes are long and very hilly. The vegetation is mainly grasses and forbs, although many areas are in secondary forest. Elevation is sea level to 200 meters.

Typically, the surface layer is dark reddish brown clay about 15 centimeters thick. The subsoil is dark red clay that is underlain by strongly weathered tuffaceous material at a depth of about 82 centimeters. Depth to saprolite ranges from 50 to 100 centimeters.

Included in this unit are small areas of Akina soils, soils that have an eroded surface layer, and Badland, which consists of soils that have been deeply gullied, exposing saprolite. Also included are small areas of soils that are moderately deep to impervious tuffaceous sandstone; gently sloping to moderately steep soils on ridgelines, benches, and foot slopes; and soils that are on short, extremely steep slopes. Included areas make up about 25 percent of the total hectarage.

Permeability of this Laolao soil is moderate. Effective rooting depth is 50 to 100 centimeters. Available water

capacity is moderate. Runoff is rapid, and the hazard of erosion is very severe.

This unit is used as watershed and wildlife habitat. It can be used for grazing and recreational development.

This unit is unsuited to commercial and subsistence farming and to homesite development because of the steepness of slope and very severe hazard of erosion.

This unit is poorly suited to grazing. The main limitations are the hazard of gully erosion and steepness of slope. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is poorly suited to recreational development. The main limitations are slope and low soil strength. Steepness of slope limits the recreational use of this unit to paths and trails.

This map unit is in capability subclass VIIe.

34—Luta cobbly clay loam, 0 to 5 percent slopes. This very shallow, well drained soil is on limestone plateaus on the island of Rota. It formed in sediment over porous limestone. Slopes are long and plane. The vegetation is mainly grasses and forbs, although many areas are forested. Elevation is 20 to 400 meters.

Typically, the surface layer is dark brown cobbly clay loam about 7 centimeters thick. The subsoil is brown cobbly clay loam to a depth of 15 centimeters. Below this is soft limestone that grades to hard limestone at a depth of about 30 centimeters. Depth to limestone commonly is 10 to 25 centimeters.

Included in this unit are small areas of limestone Rock outcrop that are commonly on slope breaks and make up as much as 10 percent of some mapped areas. Also included are small areas of Chinen soils near volcanic areas, Takpochao Variant soils near the coast, and Takpochao soils. In some areas there is less than 15 percent cobbles and pebbles in the profile, and in a few small areas the soils are very cobbly. In some areas the soils do not have a layer of soft limestone but are underlain directly by hard limestone. Occasional small pockets of soils are more than 50 centimeters deep. In some areas slopes are more than 5 percent. In areas where the profile is shallowest, the subsoil is not present or has been completely mixed into the surface layer by cultivation. A few small areas have been disturbed by construction or quarrying activity. Included areas make up as much as 15 percent of the total hectarage.

Permeability of this Luta soil is moderately rapid. Effective rooting depth is 10 to 25 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for commercial and subsistence farming, grazing, recreation, homesite development, watershed, and wildlife habitat.

This unit is poorly suited to commercial farming. Fruit trees and other deep-rooted plants are not suited to the unit. The soil in this unit is limited mainly by very shallow depth, droughtiness, and cobbles. The underlying limestone is within the plow zone, and tillage will mix gravel, cobbles, and calcareous sand from the limestone into the soil. Irrigation is necessary during the dry season. Even during the dry season, short dry periods will stress vegetable crops that are not irrigated. Because the soil is droughty, light and frequent applications of irrigation water are needed.

The limitations for subsistence farming are similar to those for commercial farming. Banana plants and fruit trees can be grown on this unit by excavating the limestone and backfilling with soil material and compost before planting.

This unit is moderately suited to grazing. The main limitation is droughtiness. Stocking rates can be adjusted to the amount of forage available.

This unit is moderately suited to homesite and urban development. The main limitation is the very shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high.

This unit is moderately suited to recreational development. The main limitations are the very shallow soil depth, droughtiness, and cobbles.

This map unit is in capability subclass IVs.

35—Luta cobbly clay loam, 5 to 15 percent slopes. This very shallow, well drained soil is on limestone plateaus on the island of Rota. It formed in sediment over porous limestone. Slopes are long and plane. The vegetation is mainly grasses and forbs, although many areas are forested. Elevation is 20 to 400 meters.

Typically, the surface layer is dark brown cobbly clay loam about 7 centimeters thick. The subsoil is brown cobbly clay loam to a depth of 15 centimeters. Below this is soft limestone that grades to hard limestone at a depth of about 30 centimeters.

Included in this unit are small areas of limestone Rock outcrop, commonly on slope breaks and in areas where slopes are about 15 percent. Also included are small areas of Chinen soils near volcanic areas, Takpochao soils, and Takpochao Variant soils near the coast. Some areas have less than 15 percent cobbles and pebbles in the soil, and a few small areas are very cobbly. Some areas do not have a layer of soft

limestone but are underlain directly with hard limestone. Slopes exceed 15 percent in a few places, and narrow, nearly level benches occur. In areas where the profile is shallowest, the subsoil is not present or has been completely mixed into the surface by cultivation. A few small areas have been disturbed by construction or quarrying activity. Included areas make up as much as 15 percent of some mapped areas.

Permeability of the Luta soil is moderately rapid. Effective rooting depth is 10 to 25 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is moderate.

This unit is used for commercial and subsistence farming, grazing, recreation, homesite development, watershed, and wildlife habitat.

This unit is poorly suited to commercial farming. Fruit trees and other deep-rooted plants are not suited to the soil in this unit. It is limited mainly by the very shallow soil depth, droughtiness, hazard of erosion, and cobbles. The underlying limestone is within the plow zone, and tillage will mix pebbles, cobbles, and calcareous sand from the limestone into the soil. Irrigation is necessary during the dry season. Even during the rainy season, short dry periods will stress vegetable crops that are not irrigated. Because the Luta soil is droughty, light and frequent applications of irrigation water are needed. All tillage should be across the slope. An erosion control system is needed. This system can include diversions, terraces, hillside ditches, and grassed waterways.

The limitations for subsistence farming are similar to those for commercial farming. Banana plants and fruit trees can be planted by excavating the limestone and backfilling with soil material and compost before planting. Clean cultivation should be avoided.

This unit is moderately suited to grazing. The main limitations are droughtiness and gully erosion on livestock trails. Stocking rates can be adjusted to the amount of forage available. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is moderately suited to homesite and urban development. The main limitations are the very shallow depth to bedrock, slope, and moderate hazard of erosion. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high.

This unit is moderately suited to recreational development. The main limitations are the very shallow soil depth, slope, droughtiness, and cobbles. Cuts and fills are necessary to establish playgrounds, ball fields, and other areas that require extensive level slopes.

This map unit is in capability subclass IVe.

36—Luta cobbly clay loam, moist, 0 to 5 percent slopes. This very shallow, well drained soil is on limestone plateaus above an elevation 400 meters on the island of Rota. It formed in sediment over porous limestone. Slopes are long and plane. The vegetation is mainly grasses and forbs. Elevation is 400 to 480 meters.

Typically, the surface layer is dark brown cobbly clay loam about 7 centimeters thick. The subsoil to a depth of 15 centimeters is brown cobbly clay loam. Below this is soft limestone that grades to hard limestone at a depth of about 30 centimeters.

Included in this unit are small areas of limestone Rock outcrop, commonly on slopes breaks. Also included are small areas of Chinen soils near Mount Manira and Takpochao soils; in some mapped areas the soils have less than 15 percent cobbles and pebbles in the profile, and in a few small areas the soils are very cobbly. In some areas the soils do not have a layer of soft limestone but are underlain directly by hard limestone. Occasional small pockets of soil are deeper than 50 centimeters. In a few places are soils that have slopes of more than 5 percent. In areas where the soils have the shallowest profiles, the subsoil is not present or has been completely mixed into the surface by cultivation. A few small areas have been disturbed by mining activity. Included areas make up as much as 15 percent of some units, but in most places are less than 10 percent of the unit.

Permeability of this Luta soil is moderately rapid. Effective rooting depth commonly is 10 to 25 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight. This soil remains moist from July to December.

This unit is used for commercial and subsistence farming, watershed, and wildlife habitat. It can be used for grazing and for homesite and recreational development.

This unit is moderately suited to commercial farming. Crops that prefer cool temperatures can be grown on this unit. Fruit trees and other deep-rooted plants are not suited to this unit. It is limited mainly by very shallow soil depth, droughtiness, and cobbles. The underlying limestone is within the plow zone, and tillage mixes gravel, cobbles, and calcareous sand from the limestone into the soil. Irrigation is necessary during the dry season for maximum production of vegetables. Crops can be grown without irrigation further into the dry season on the soil in this unit than on Luta soils at

lower elevations. Because the Luta soil in this unit is droughty, light and frequent applications of irrigation water are needed. All tillage should be across the slope.

The limitations for subsistence farming are similar to those for commercial farming. Banana plants or fruit trees can be grown on this unit by excavating the limestone and backfilling with soil material and compost before planting. Strong winds can damage crops such as bananas.

This unit is well suited to grazing. The main limitation is short periods of droughtiness. Stocking rates should be adjusted to the amount of forage available.

This unit is moderately suited to homesite and urban development. The main limitation is the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. Soil material can be stockpiled and used to reclaim areas disturbed during construction.

This unit is moderately suited to recreational development. The main limitations are very shallow soil depth, cobbles, and droughtiness. Cobbles can be removed from playground areas.

This map unit is in capability subclass IVs.

37—Luta cobbly clay loam, moist, 5 to 15 percent slopes. This very shallow, well drained soil is on limestone plateaus on the island of Rota. It formed in sediment over porous limestone. Slopes are long and plane. The vegetation is mainly grasses and forbs.

Typically, the surface layer is dark brown cobbly clay loam about 7 centimeters thick. The subsoil to a depth of 15 centimeters is brown cobbly clay loam. Below this is soft limestone that grades to hard limestone at a depth of about 30 centimeters. Depth to limestone commonly is 10 to 25 centimeters.

Included in this unit are small areas of limestone Rock outcrop, commonly on slope breaks and in areas where slopes are about 15 percent. Also included are small areas of Chinen soils near Mount Manira and Takpochao soils. Some areas have less than 15 percent cobbles and pebbles in the soil, and a few small areas are very cobbly. Many areas do not have a layer of soft limestone but are underlain directly with hard limestone. Occasional small pockets of soil are deeper than 50 centimeters. In a few places are soils that have slopes of more than 15 percent, and narrow, nearly level benches occur. In areas where the soil profile is shallowest, the subsoil is not present or has been completely mixed into the surface by cultivation. A few small areas have been disturbed by mining activity. Included areas make up as much as 15 percent of some mapped areas, but in most places are less than 10 percent of mapped areas.

Permeability of this Luta soil is moderately rapid. Effective rooting depth is 10 to 25 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is moderate. This soil remains moist from July to December.

This unit is used for commercial and subsistence farming, watershed, and wildlife habitat. It can be used for grazing, homesite development, and recreation.

This unit is moderately suited to commercial farming. Crops that prefer cool temperatures can be grown on the unit. Fruit trees and other deep-rooted plants are not suited to the soil in this unit. It is limited mainly by very shallow soil depth, droughtiness, the hazard of erosion, and cobbles. The underlying limestone is within the plow zone, and tillage mixes gravel, cobbles, and calcareous sand from the limestone into the soil. Irrigation is necessary during the dry season for maximum production of vegetables. Crops can be grown without irrigation longer into the dry season on the soil in this unit than on the Luta soils at lower elevations. Because the soil in this unit is droughty, light and frequent applications of irrigation water are needed. All tillage should be across the slope. An erosion control system is needed. This system can include diversions, terraces, hillside ditches, and grassed waterways.

The limitations for subsistence farming are similar to those for commercial farming. Banana plants or fruit trees can be grown on this unit by excavating the limestone and backfilling with soil material and compost before planting. Clean cultivation should be avoided where feasible. Strong winds can damage crops such as bananas.

This unit is well suited to grazing. The main limitations are short periods of droughtiness and gully erosion on livestock trails. Stocking rates can be adjusted to the amount of forage available. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is moderately suited to homesite and urban development. The main limitations are the very shallow depth to bedrock, slope, and moderate hazard of erosion. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. Preserving the existing

plant cover during construction helps to control erosion. Soil material can be stockpiled and used to reclaim areas disturbed during construction.

This unit is moderately suited to recreational development. The main limitations are the very shallow soil depth, slope, cobbles, and droughtiness. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level slopes. Soil must be stockpiled and used to reclaim the area. Cobbles can be removed from playground areas.

This map unit is in capability subclass IVe.

38—Luta-Rock outcrop complex, 0 to 5 percent slopes. This map unit is on limestone plateaus on the island of Rota. Slopes are long and plane. The vegetation is mainly native forest. Elevation is 20 to 480 meters.

This unit is about 60 percent Luta cobbly clay loam and 25 percent limestone Rock outcrop. The components of this unit are so intricately intermingled that it was not feasible to map them separately at the scale used.

Included in this unit are small areas of Takpochao soils. Also included are small areas of soils that are similar to the Luta soil but are more than 35 percent pebbles and cobbles, soils that have slopes of more than 5 percent, and shallow soils that do not have a subsoil. Included areas make up about 15 percent of the unit, but they make up as much as 20 percent of some mapped areas.

The Luta soil is very shallow and well drained. It formed in sediment over porous limestone. Typically, the surface layer is dark brown cobbly clay loam about 7 centimeters thick. The subsoil to a depth of 15 centimeters is brown cobbly clay loam. Below this is hard limestone. Depth to limestone commonly is 10 to 25 centimeters. The profile is about 25 to 35 percent pebbles and cobbles.

Permeability of the Luta soil is moderately rapid. Effective rooting depth is 10 to 25 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is moderate.

The Rock outcrop is white, porous limestone. Typically, the surface is jagged and irregular and protrudes well above the soil surface. Organic debris, soil material, and roots are in cracks and interstices. Permeability is rapid, and runoff is slow. Distance between the individual outcroppings ranges from less than 1 meter to about 10 meters.

This unit is used as watershed and wildlife habitat. It can be used for subsistence farming, grazing, homesite and urban development, and recreational development.

The areas of Rock outcrop make this unit unsuitable for commercial farming.

This unit is poorly suited to subsistence farming. It is limited by the areas of Rock outcrop, very shallow soil depth, and droughtiness. Crops can be planted only at irregular intervals between the areas of Rock outcrop. Vehicle access and mechanical tillage are restricted by the areas of Rock outcrop. Banana plants or fruit trees can be grown on the soil in this unit by excavating the limestone and backfilling with soil material and compost before planting. Irrigation is necessary during the dry season.

This unit is poorly suited to grazing. The main limitations are the areas of Rock outcrop. Most areas of this unit are heavily forested and forage production is very low. The areas of Rock outcrop limit the pasture management practices that can be used.

This unit is poorly suited to homesite and urban development. The main limitations are the areas of Rock outcrop and very shallow depth to bedrock. Excavation is difficult because of the very shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high.

This unit is poorly suited to recreational development. The main limitation is the areas of Rock outcrop. These areas limit the recreational use of this unit to a few paths and trails.

The Luta soil is in capability subclass IVs, and Rock outcrop is in capability subclass VIIIs.

39—Luta-Rock outcrop complex, 5 to 15 percent slopes. This map unit is on limestone plateaus on the island of Rota. Slopes are long and plane. The vegetation is mainly native forest. Elevation is 20 to 480 meters.

This unit is about 60 percent Luta cobbly clay loam and 25 percent limestone Rock outcrop. The components of this unit are so intricately intermingled that it was not feasible to map them separately at the scale used.

Included in this unit are small areas of Takpochao soils. Also included are soils that are similar to the Luta soil but are more than 35 percent pebbles and cobbles, soils that have slopes of more than 15 percent, nearly level soils on narrow benches, and shallow soils that do not have a subsoil. Included areas make up about 15 percent of most mapped areas, but they make up as much as 20 percent of some areas.

The Luta soil is very shallow and well drained. It

formed in sediment over porous limestone. Typically, the surface layer is dark brown cobbly clay loam about 7 centimeters thick. The subsoil is brown cobbly clay loam to a depth of 15 centimeters. Below this is hard limestone. Depth to limestone commonly is 10 to 25 centimeters.

Permeability of the Luta soil is moderately rapid. Effective rooting depth is 10 to 25 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is moderate.

The Rock outcrop is white, porous limestone. Typically, the surface is jagged and irregular and protrudes well above the soil surface. Organic debris, soil material, and roots are in cracks and interstices. Permeability is rapid, and runoff is slow. Distance between the individual outcroppings ranges from less than 1 meter to about 5 meters.

This unit is used as watershed and wildlife habitat. It can be used for subsistence farming, grazing, homesite and urban development, and recreational development.

The areas of Rock outcrop make this unit unsuitable for commercial farming.

This unit is poorly suited to subsistence farming. It is limited by the areas of Rock outcrop, very shallow soil depth, droughtiness, and hazard of erosion. Crops can be planted only at irregular intervals between the areas of Rock outcrop. Vehicle access and mechanical tillage are restricted by the areas of Rock outcrop. Banana plants or fruit trees can be grown on this unit by excavating the limestone and backfilling with soil material and compost before planting. Irrigation is necessary during the dry season. Clean cultivation should be avoided.

This unit is poorly suited to grazing. The main limitation is the areas of Rock outcrop. Most areas of this unit are heavily forested, and forage production is very low. The areas of Rock outcrop limit the pasture management practices that can be used.

This unit is poorly suited to homesite and urban development. The main limitations are the areas of Rock outcrop, very shallow depth to bedrock, slope, and moderate hazard of erosion. Excavation is difficult because of the shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high. Preserving the existing plant cover during construction helps to control erosion. Soil material can be stockpiled and used to reclaim areas disturbed during construction. These areas can be revegetated to control erosion.

This unit is poorly suited to recreational development. The main limitation is the areas of Rock outcrop. These areas limit the recreational use of this unit to a few paths and trails.

The Luta soil is in capability subclass IVe, and the Rock outcrop is in capability subclass VIIIs.

40—Luta-Rock outcrop complex, 15 to 30 percent slopes. This map unit is on limestone plateaus and escarpments on the island of Rota. Most areas are long and narrow in shape. Slopes are long and plane. The vegetation is mainly native forest. Elevation is 20 to 480 meters.

This unit is about 60 percent Luta cobbly clay loam and 35 percent limestone Rock outcrop. The components of this unit are so intricately intermingled that it was not feasible to map them separately at the scale used.

Included in this unit are small areas of Takpochao soils. Also included are soils that are similar to the Luta soil but are more than 35 percent pebbles and cobbles, soils that have slopes of more than 30 percent and include vertical cliffs, nearly level to gently sloping soils on narrow benches, and shallow soils that do not have a subsoil. Included areas make up about 15 percent of most mapped areas, but they make up as much as 20 percent of some areas.

The Luta soil is very shallow and well drained. It formed in sediment over porous limestone. Typically, the surface layer is dark brown cobbly clay loam about 7 centimeters thick. The subsoil to a depth of 15 centimeters is brown cobbly clay loam. Below this is hard limestone. Depth to limestone commonly is 10 to 25 centimeters.

Permeability of the Luta soil is moderately rapid. Effective rooting depth is 10 to 25 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is severe.

The Rock outcrop is white, porous limestone. Typically, the surface is jagged and irregular. It protrudes well above the soil surface in some places. Organic debris, soil material, and roots are in cracks and interstices. Permeability is rapid, and runoff is slow. Distance between the individual outcroppings ranges from less than 1 meter to about 2 meters.

This unit is used as watershed and wildlife habitat. It can be used for subsistence farming, grazing, and recreational development.

The areas of Rock outcrop and slope make this unit unsuitable for commercial farming or homesite development.

This unit is poorly suited to subsistence farming. It is

limited by the areas of Rock outcrop, the severe hazard of erosion, very shallow soil depth, and droughtiness. Crops can be planted only at irregular intervals between the areas of Rock outcrop. Vehicle access and mechanical tillage are restricted by the areas of Rock outcrop and the steepness of slope. Banana plants or fruit trees can be grown on this unit by excavating the limestone and backfilling with soil material and compost before planting. Clean cultivation should be avoided. Irrigation is necessary during the dry season.

This unit is poorly suited to grazing. The main limitations are the areas of Rock outcrop and the hazard of gully erosion on livestock trails. Most areas of this unit are heavily forested, and forage production is very low. The areas of Rock outcrop and steepness of slope limit the pasture management practices that can be used.

This unit is poorly suited to recreational development. The main limitations are the areas of Rock outcrop and steepness of slope. These limitations restrict the recreational use of this unit to a few paths and trails, which should extend across the slope.

The Luta soil is in capability subclass VIe, and the Rock outcrop is in capability subclass VIIIs.

41—Mesei Variant muck, 0 to 2 percent slopes. This very deep, very poorly drained soil is in level parts of depressional areas on the islands of Saipan and Tinian. It formed in marine deposits, alluvium, and organic material. Vegetation is mainly solid stands of the water-tolerant reed called kariso. Elevation is sea level to 5 meters.

Typically, the surface layer is black muck about 20 centimeters thick. Below this to a depth of about 60 centimeters is very dark gray gravelly mucky clay loam and dark olive gray gravelly mucky sandy loam. The substratum is gray very gravelly sandy loam. The gravel is angular clam shells and coral fragments.

Included in this unit are small areas of Inarajan soils near the edges of uplands, areas of open water, and soils that are more than 100 centimeters deep to a very gravelly substratum. Also included are small areas of soils that are underlain by cemented sand, soils that are underlain by silty marine deposits, and soils that have a sandy surface layer. Other areas were disturbed during World War II and contain limestone gravel fill, fragments of concrete, metal artifacts, and other debris. Large amounts of debris were bulldozed into Susupe Swamp on the island of Saipan.

Permeability of the Mesei Variant soil is moderate to a depth of 60 centimeters and rapid below this depth. Effective rooting depth is more than 150 centimeters. Runoff is ponded. A permanent high water table fluctuates between the surface and more than 1 meter above the surface.

This unit is used as watershed and wildlife habitat. It can be used for subsistence farming and recreational development.

This unit is unsuitable for commercial farming, grazing, or urban development. It is limited by the high water table, frequent flooding, and potential subsidence of the organic material if the unit is drained.

This unit is poorly suited to subsistence farming. Only water-tolerant crops such as wetland taro and rice can be grown. Vehicle access and mechanical tillage are not feasible because of the high water table.

This unit is poorly suited to homesite and urban development. The main limitations are the high water table, low soil strength, and flooding.

This unit is poorly suited to recreational development. It is limited by the high water table, flooding, and low soil strength. Lakes within this unit such as Lake Susupe provide some recreational opportunities.

This map unit is in capability subclass VIIw.

42—Rock outcrop-Takpochao complex, 60 to 99 percent slopes. This map unit is on limestone plateau escarpments and canyon side slopes on the islands of Saipan, Tinian, Aguijan, and Rota. Slopes are broken by vertical cliff faces and narrow ledges. The vegetation is mainly native forest and shrubs. Elevation is 5 to 465 meters.

This unit is 50 percent limestone Rock outcrop and 40 percent Takpochao very cobbly clay. The components of this unit are so intricately intermingled that it was not feasible to map them separately at the scale used.

Included in this unit are small areas of Chinen soils on Saipan, Tinian, and Aguijan and Luta soils on Rota. Vertical cliffs occupy some areas of this unit. Very cobbly clay loam or very cobbly loam is in many places.

The Rock outcrop is white, porous coralline limestone. Typically, the surface is jagged and irregular. It protrudes well above the soil surface in some places. Organic debris, soil material, and roots are in cracks and interstices. Permeability is rapid, and runoff is slow. Distance between the individual outcroppings commonly is less than 1 meter.

The Takpochao soil is shallow and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is black very cobbly mucky loam about 3 centimeters thick over very dark grayish brown very cobbly clay about 15 centimeters thick. The subsoil to a depth of about 30 centimeters is dark

yellowish brown very cobbly clay over limestone. The surface of the underlying limestone is jagged and irregular. Depth to porous limestone is dominantly 10 to 25 centimeters. On Rota, the depth to limestone is more uniform.

Permeability of the Takpochao soil is moderate. Effective rooting depth is 10 to 25 centimeters. Some roots extend into pockets of deeper soil material. Available water capacity is low. Runoff is rapid, and the hazard of water erosion is severe.

This unit is used as watershed and wildlife habitat. It can be used for recreational development.

This unit is unsuited to commercial and subsistence farming, grazing, and homesite development. It is limited by steepness of slope.

This unit is poorly suited to recreational development because of the steepness of slope, which restricts the recreational use of this unit to a few paths and trails.

The Rock outcrop is in capability subclass VIIIs, and the Takpochao soil is in capability subclass VIIe.

43—Saipan clay, 0 to 5 percent slopes. This deep, well drained soil is on limestone plateaus on the islands of Saipan and Tinian. It formed in sediment over porous, coralline limestone. Slopes are long and plane. The vegetation is mainly secondary forest. Elevation is 10 to 400 meters.

Typically, the surface layer is dark brown clay about 9 centimeters thick over dark reddish brown clay about 7 centimeters thick. The subsoil to a depth of 120 centimeters is reddish brown and yellowish red silty clay and clay. Limestone is at a depth of about 120 centimeters.

Included in this unit are small areas of Chinen, Dandan, and Kagman soils, Chacha soils in depressional areas, and sandy spots along the coast. Also included are small areas of limestone quarries, soils that have short, steep slopes, and areas that were disturbed during World War II. Bulldozed areas, limestone gravel fill, and piles of concrete and other rubble are in these areas. Included areas make up about 20 percent of the total hectarage.

Permeability of the Saipan soil is moderate. Effective rooting depth is more than 100 centimeters. Available water capacity is high. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for commercial and subsistence farming, grazing, homesite and recreational development, watershed, and wildlife habitat.

This unit is well suited to commercial and subsistence farming and to grazing. It has few limitations.

This unit is moderately suited to homesite and urban development. The main limitation is low soil strength. Before constructing buildings or roads, gravel fill can be spread on the site to improve the load supporting capacity of the soil.

This unit is moderately suited to recreational development. The main limitation is low soil strength.

This map unit is in capability subclass IIs.

44—Saipan clay, 5 to 15 percent slopes. This deep, well drained soil is on limestone plateaus on the islands of Saipan and Tinian. It formed in sediment over porous, coralline limestone. Slopes are long and plane. The vegetation is mainly secondary forest. Elevation is 10 to 400 meters.

Typically, the surface layer is dark brown clay about 9 centimeters thick over dark reddish brown clay about 7 centimeters thick. The subsoil to a depth of 120 centimeters is reddish brown and yellowish red silty clay and clay. Limestone is at a depth of about 120 centimeters.

Included in this unit are small areas of Chinen, Dandan, and Kagman soils and Chacha soils in depressions. Also included are small areas of nearly level soils, steep soils, and areas of soils that were disturbed during World War II. Bulldozed areas, limestone gravel fill, and piles of concrete and other rubble are in these areas. Included areas make up about 20 percent of the total hectarage.

Permeability of the Saipan soil is moderate. Effective rooting depth is more than 100 centimeters. Available water capacity is high. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used for commercial and subsistence farming, grazing, homesite and recreational development, watershed, and wildlife habitat.

This unit is moderately suited to commercial farming. It is limited by the moderate hazard of erosion. All tillage should be across the slope. An erosion control system is needed. This system can include diversions, terraces, hillside ditches, and grassed waterways.

The limitations for subsistence farming are similar to those for commercial farming. Clean cultivation should be avoided.

This unit is well suited to grazing. It is limited by the hazard of gully erosion on livestock trails. Using proper stocking rates and rotation grazing prevents extensive trailing.

This unit is moderately suited to homesite and urban development. The main limitations are the slope, moderate hazard of erosion, and low soil strength. Preserving the existing plant cover during construction

helps to control erosion. Revegetating disturbed areas around construction sites as soon as feasible helps to control erosion. The bearing capacity of the soil is improved by spreading gravel fill on the site before constructing roads.

This unit is moderately suited to recreational development. The main limitations are the slope and low soil strength. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level slopes.

This map unit is in capability subclass IIIe.

45—Saipan very gravelly sandy loam, 0 to 5 percent slopes. This very deep, well drained soil is on limestone plateaus on the islands of Saipan and Tinian. It formed in fill material that was spread over the natural soil surface during World War II. Slopes are long and plane. The vegetation is mainly secondary forest. Some areas are in grasses and forbs. Elevation is 10 to 400 meters.

Typically, the surface layer is very gravelly sandy loam fill material about 20 centimeters thick. Below this is a buried surface layer of dark brown and dark reddish brown clay 16 centimeters thick. The subsoil to a depth of 140 centimeters is reddish yellow and yellowish red clay and silty clay over limestone. Limestone is at a depth of about 140 centimeters.

Included in this unit are small areas of bunkers, piles of concrete and rubble, gravel pads more than 25 centimeters thick, bulldozed excavations, and other areas disturbed during World War II. Also included are small areas of Chinen, Dandan, and Saipan soils that have little or no fill material, Urban land, and soils that have short, steep slopes. Included areas make up about 10 percent of the total hectarage.

Permeability of the Saipan soil is moderate. Effective rooting depth is more than 120 centimeters. Available water capacity is high. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for homesite development, watershed, and wildlife habitat. It can be used for grazing, recreational development, and subsistence or commercial farming.

This unit is poorly suited to commercial farming. It is limited mainly by the very gravelly fill material and presence of debris from World War II. The very gravelly fill material must be scraped off with a bulldozer before crops can be grown. All tillage should be across the slope.

The limitations for subsistence farming are similar to those for commercial farming. The very gravelly fill material must be excavated before crops can be grown. Individual holes can be dug for fruit trees and banana plants.

This unit is moderately suited to grazing. The main limitation is droughtiness of the surface layer. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion.

This unit is well suited to homesite and urban development. The main limitation is the very gravelly fill material, which interferes with establishment of lawns and landscaping plants.

This unit is moderately suited to recreational development. The main limitations are droughtiness and the very gravelly fill material.

This map unit is in capability subclass IVs.

46—Saipan very gravelly sandy loam, 5 to 15 percent slopes. This very deep, well drained soil is on limestone plateaus on the island of Saipan. It formed in fill material that was spread over the natural soil surface during World War II. Slopes are long and plane and are broken in places by cuts and fills made during construction. The vegetation is mainly secondary forest. Some areas are in grasses and forbs. Elevation is 10 to 400 meters.

Typically, the surface layer is very gravelly sandy loam fill material about 20 centimeters thick. Below this is a buried surface layer of dark brown and dark reddish brown clay 16 centimeters thick. The subsoil to a depth of more than 150 centimeters is reddish brown and yellowish red clay and silty clay over limestone. Depth to limestone is about 150 centimeters.

Included in this unit are small areas of bunkers, piles of concrete and rubble, gravel pads more than 25 centimeters thick, bulldozed excavations, and other areas disturbed during World War II. Also included are small areas of Chinen, Dandan, and Saipan soils that have little or no fill material, Urban land, level soils, and soils that have short, steep slopes. Included areas make up about 20 percent of the total hectarage.

Permeability of the Saipan soil is moderate. Effective rooting depth is more than 120 centimeters. Available water capacity is high. Runoff is medium, and the hazard of water erosion is slight.

This unit is used for homesite development, watershed, and wildlife habitat. It can be used for grazing, recreational development, and subsistence or commercial farming.

This unit is poorly suited to commercial crops. It is limited mainly by the very gravelly fill material and debris from World War II. The very gravelly fill material must be scraped off with a bulldozer before crops can

be grown. Some areas contain bunkers, piles of debris, and pavement. All tillage should be across the slope.

The limitations for subsistence farming are similar to those for commercial farming. The very gravelly fill material must be excavated before crops can be grown. Individual holes can be dug for fruit trees and banana plants.

This unit is moderately suited to grazing. The main limitation is droughtiness of the surface layer. Using cross-fencing and deferred grazing and avoiding overgrazing help to keep the pasture in good condition and to protect the soil from erosion.

This unit is moderately suited to homesite and urban development. The main limitations are slope and the very gravelly fill material. Slope is a concern in installing septic tank absorption fields. The very gravelly fill material will interfere with establishment of lawns and landscaping plants.

This unit is moderately suited to recreational development. The main limitations are slope, droughtiness, and the very gravelly fill material. Cuts and fills must be made to establish playgrounds, ball fields, and other areas that require extensive level areas.

This map unit is in capability subclass VIe.

47—Saipan-Rock outcrop complex, 0 to 5 percent slopes. This map unit is on limestone plateaus on the island of Aguijan. Slopes are long and concave. The vegetation is mainly grasses and forbs. Elevation is 130 to 150 meters.

This unit is 70 percent Saipan clay and 15 percent limestone Rock outcrop. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit is about 15 percent Chinen and Dandan soils. In some areas as much as 20 percent of the surface is covered by cobbles. In a few areas slopes are more than 5 percent. Included areas make up about 15 percent of the total hectarage.

The Saipan soil is deep and well drained. It formed in sediment over porous coralline limestone. Typically, the surface layer is dark brown clay about 9 centimeters thick over dark reddish brown clay about 7 centimeters thick. The subsoil to a depth of more than 120 centimeters is reddish brown and yellowish red clay and silty clay over limestone. Depth to limestone is about 120 centimeters.

Permeability of the Saipan soil is moderate. Effective rooting depth is more than 100 centimeters. Available water capacity is high. Runoff is slow, and the hazard of water erosion is slight.

The Rock outcrop is white, porous coralline limestone. Most outcroppings are about 50 to 100 centimeters across and protrude about 5 to 100 centimeters above the soil surface. Distance between the individual outcroppings ranges from less than 1 meter to about 10 meters.

This unit is used as wildlife habitat. It can be used for recreational development, subsistence farming, and grazing.

This unit is unsuited to commercial farming.

This unit is poorly suited to subsistence farming. It is limited mainly by the areas of Rock outcrop, which interfere with tillage. Most Rock outcrop can be avoided with the use of small rototillers or by hand cultivation. Fruit crops are best suited to the unit because individual trees or banana plants can be planted in the pockets of the Saipan soil that are between the areas of Rock outcrop.

This unit is moderately suited to grazing. The main limitation is the areas of Rock outcrop, which limit the pasture management practices that can be used.

Homesite development is feasible, but Aguijan is uninhabited by law.

The Saipan soil is moderately suited to recreational development. It is limited by the areas of Rock outcrop and low soil strength. Areas of Rock outcrop interfere with the placement of buildings or roads. The bearing capacity of the Saipan soil is improved by spreading gravel fill on the site before constructing buildings or roads.

The Saipan soil is in capability subclass IIs, and the Rock outcrop is in capability subclass VIIIs.

48—Shioya loamy sand, 0 to 3 percent slopes. This very deep, excessively drained soil is on coastal strands on the islands of Saipan, Tinian, and Rota. It formed in water-deposited coral sand. Areas are typically long, narrow, and parallel to the shore line. Slopes are long and plane. The vegetation is mainly forest. Elevation is sea level to 10 meters.

Typically, the surface layer is very dark gray loamy sand about 19 centimeters thick. Below this to a depth of 160 centimeters is very pale brown sand. Depth to cemented sand, coral rubble, or porous bedrock is more than 150 centimeters.

Included in this unit are small areas of Saipan and Mesei Variant soils on the island of Saipan, Urban land, and Shioya soils that have a sandy loam surface layer. Takpochao Variant soils are included on Rota. On Saipan and Tinian there are small areas that were disturbed during World War II. Bulldozed areas and piles of concrete and other rubble are in these areas.

Included areas make up about 10 percent of the total hectarage.

Permeability of the Shioya soil is rapid. Effective rooting depth is more than 150 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for subsistence farming, wildlife habitat, watershed, and homesite and recreational development. It can be used for commercial farming and grazing.

This unit is poorly suited to commercial and subsistence farming. It is limited mainly by droughtiness and high salt content. Salt-sensitive crops are not suited to the unit. Irrigation is necessary during the dry season. Even during the rainy season, short dry periods stress vegetable crops that are not irrigated. Because the soil in this unit is droughty, light and frequent applications of irrigation water are necessary. Windbreaks are needed on the side facing the ocean.

This unit is moderately suited to grazing. It is limited mainly by droughtiness. Stocking rates should be adjusted to the amount of forage available.

This unit is well suited to homesite and urban development. The main limitation is the hazard of wave damage during typhoons in some areas. Buildings should be constructed as far from the ocean as feasible. Septic tank absorption fields will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of ground water and beach areas as a result of seepage from onsite sewage disposal systems.

This unit is moderately suited to recreational development. The main limitations are the hazard of wave damage during typhoons along the coast and droughtiness. A wide forested buffer strip can be maintained along the ocean coastline.

This map unit is in capability subclass IVs.

49—Shioya-Urban land complex, 0 to 3 percent slopes. This map unit is on coastal strands on the islands of Saipan, Tinian, and Rota. Slopes are long and plane. Elevation is sea level to 10 meters.

This unit is 60 percent Shioya loamy sand and 30 percent Urban land. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Saipan and Mesei Variant soils on the island of Saipan, Shioya soils that were disturbed during construction, and Shioya soils that have been covered with limestone gravel fill. Takpochao Variant soils are included on Rota. On Saipan and Tinian there are small areas of soils that were disturbed during World War II. Bulldozed areas and piles of concrete and other rubble are in these areas. Included areas make up about 10 percent of the total hectarage.

The Shioya soil is deep and excessively drained. It formed in water-deposited limestone sand derived from coral reef formations. Typically, the surface layer is very dark gray loamy sand about 19 centimeters thick. Below this to a depth of 160 centimeters is very pale brown sand. Depth to cemented sand, coral rubble, or porous bedrock is more than 150 centimeters.

Permeability of the Shioya soil is rapid. Effective rooting depth is more than 150 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

Urban land consists of paved or impervious surfaces such as roads, buildings, and parking lots. These areas have a base of limestone gravel fill. The only vegetation is a few pioneer species that root along fractures in the pavement.

This unit is used for homesite and urban development. It can be used for recreational development and subsistence farming.

This unit is poorly suited to subsistence farming. Only the Shioya soil is suitable for crops. It is limited mainly by droughtiness and high salt content. Irrigation is necessary during the dry season. Crops should be planted as far from the open coastline as feasible. Windbreaks are needed on the side facing the ocean.

This unit is well suited to homesite and urban development. The main limitation is the hazard of wave damage in some areas during typhoons. Buildings should be constructed as far from the ocean as feasible. Septic tank absorption fields will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of ground water and beach areas as a result of seepage from onsite sewage disposal systems.

This unit is moderately suited to recreational development. It is limited mainly by the areas of Urban land, droughtiness, and the hazard of wave damage during typhoons along the coast. A wide forested buffer strip can be maintained along the open coastline.

The Shioya soil is in capability subclass IVs. Urban land is not assigned a capability classification.

50—Takpochao-Rock outcrop complex, 3 to 15 percent slopes. This map unit is on limestone plateaus on the islands of Saipan, Tinian, Aguijan, and Rota. Slopes are long and plane, but they are broken by

occasional short escarpments. The vegetation is mainly native forest, but shrubs and low trees are in windward coastal areas. Elevation is 5 to 465 meters.

This unit is 50 percent Takpochao very cobbly clay and 40 percent limestone Rock outcrop. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Chinen and Dandan soils on Saipan, Tinian, and Aguijan. On Rota there are areas of Luta and Takpochao Variant soils. Sandy spots are present in a few places adjacent to the ocean. Areas along the coast have a continuous vertical escarpment facing the ocean. Included areas make up about 10 percent of the total hectarage.

The Takpochao soil is very shallow and well drained. It formed in sediment overlying porous corraline limestone. Typically, the surface layer is black very cobbly loam about 3 centimeters thick over very dark grayish brown very cobbly clay about 15 centimeters thick. The subsoil to a depth of about 30 centimeters is dark yellowish brown very cobbly clay over limestone. The surface of the underlying limestone is jagged and irregular. Depth to porous coralline limestone is dominantly 10 to 25 centimeters.

Permeability of the Takpochao soil is moderate. Effective rooting depth is 10 to 25 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

The Rock outcrop is white, porous coralline limestone. Typically, the surface is jagged and irregular. It protrudes well above the soil surface in some places. Organic debris, soil material, and roots are in cracks and interstices.

This unit is used as watershed and wildlife habitat. It can be used for homesite and recreational development.

This unit is unsuited to commercial and subsistence farming and grazing. It is limited by the areas of Rock outcrop and very shallow soil depth.

This unit is poorly suited to homesite and urban development. The main limitations are the areas of Rock outcrop, shallow depth to bedrock, and slope. Excavation is difficult because of shallow depth to bedrock. The underlying limestone does not properly filter the effluent from septic tank absorption fields. This effluent can contaminate the ground water. Community sewage systems are needed where the density of housing is moderate to high.

This unit is poorly suited to recreational development. The main limitation is the areas of Rock outcrop, which limit the use of this unit to a few paths and trails.

The Takpochao soil is in capability subclass VIIs, and Rock outcrop is in capability subclass VIIIs.

51—Takpochao-Rock outcrop complex, 15 to 30 percent slopes. This map unit is on tilted limestone plateaus on the islands of Saipan, Tinian, and Aguijan. Slopes are long and plane, but they are broken by occasional short escarpments. The vegetation is mainly native forest. Elevation is 5 to 465 meters.

This unit is 50 percent Takpochao very cobbly clay and 40 percent limestone Rock outcrop. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Chinen and Dandan soils, limestone quarries, nearly level benches, and steep escarpments. Included areas make up about 10 percent of the total hectarage.

The Takpochao soil is shallow and well drained. It formed in sediment overlying porous coralline limestone. Typically, the surface layer is black very cobbly loam about 3 centimeters thick over very dark grayish brown very cobbly clay about 15 centimeters thick. The subsoil to a depth of about 30 centimeters is dark yellowish brown very cobbly clay over limestone. The surface of the underlying limestone is jagged and irregular. Depth to porous coralline limestone is dominantly 10 to 25 centimeters.

Permeability of the Takpochao soil is moderate. Effective rooting depth is 10 to 25 centimeters. Available water capacity is low. Runoff is medium, and the hazard of water erosion is moderate.

The Rock outcrop is white, porous coralline limestone. Typically, the surface is jagged and irregular. It protrudes well above the soil surface in some places. Organic debris, soil material, and roots are in cracks and interstices.

This unit is used as watershed and wildlife habitat. It can be used for recreational development.

This unit is unsuited to commercial and subsistence farming, grazing, and homesite development. It is limited by the areas of Rock outcrop, very shallow soil depth, and steepness of slope.

This unit is poorly suited to recreational development. The main limitation is the areas of Rock outcrop, which limit the use of this unit to a few paths and trails.

The Takpochao soil is in capability subclass VIIe, and Rock outcrop is in capability subclass VIIIs.

52—Takpochao-Rock outcrop complex, 30 to 60 percent slopes. This map unit is on limestone plateau escarpments, canyon side slopes, and knolls on the

islands of Saipan, Tinian, Aguijan, and Rota. Slopes are broken by narrow benches and vertical cliffs. The vegetation is mainly native forest.

This unit is 50 percent Takpochao very cobbly clay and 40 percent Rock outcrop. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Chinen and Dandan soils on Saipan, Tinian, and Aguijan. On Rota there are inclusions of Luta and Takpochao Variant soils. Also included are areas of gently sloping soils on benches and areas of soils that have slopes of more than 60 percent. Included areas make up about 10 percent of the total hectarage.

The Takpochao soil is very shallow and well drained. It formed in sediment overlying porous coralline limestone. Typically, the surface layer is black very cobbly mucky loam about 3 centimeters thick over very dark grayish brown very cobbly clay about 18 centimeters thick. The subsoil to a depth of about 30 centimeters is dark yellowish brown very cobbly clay over limestone. The surface of the underlying limestone is jagged and irregular. Depth to porous coralline limestone is dominantly 10 to 25 centimeters.

Permeability of the Takpochao soil is moderate. Effective rooting depth is 10 to 25 centimeters. Available water capacity is low. Runoff is very rapid.

The Rock outcrop is white, porous coralline limestone. Typically, the surface is jagged and irregular. It protrudes well above the soil surface in some places. Organic debris, soil material, and roots are in cracks and interstices. Permeability is rapid, and runoff is very slow.

This unit is used as watershed and wildlife habitat. It can be used for recreational development.

This unit is unsuited to commercial and subsistence farming, grazing, and homesite development. It is limited by steepness of slope and the areas of Rock outcrop.

This unit is poorly suited to recreational development. The main limitation is the areas of Rock outcrop. These areas limit the use of this unit to a few paths and trails.

The Takpochao soil is in capability subclass VIIs, and the Rock outcrop is in capability subclass VIIIe.

53—Takpochao Variant-Shioya complex, 1 to 10 percent slopes. This map unit is on coastal limestone plateaus on the island of Rota. Slopes are long and plane, but they are broken in places by narrow benches and short, steep escarpments. The vegetation is mainly forest except in urbanized areas. Elevation is 0 to 10 meters.

This unit is about 60 percent Takpochao Variant very gravelly sandy loam and 30 percent Shioya loamy sand. The Takpochao Variant soil is in narrow, sloping areas adjacent to the unvegetated shoreline and on the landward slopes above the Shioya soil. The Shioya soil is on a nearly level bench about 5 meters above high tide level. The Shioya soil has slopes of 1 to 3 percent, and the Takpochao Variant soil has slopes of 3 to 10 percent. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of limestone Rock outcrop that are on slope breaks and are associated with the Takpochao Variant soil. Also included are areas covered by roads and buildings, soils that have short, steep slopes, and Luta soils near the landward soil boundary. Included areas make up about 10 percent of this unit.

The Takpochao Variant soil is very shallow and excessively drained. It formed in water-deposited limestone sand and residuum derived from the underlying limestone. Typically, the soil is 15 centimeters of black to very dark gray very gravelly sandy loam over hard, porous limestone. Depth to limestone is 10 to 50 centimeters.

Permeability of the Takpochao Variant soil is rapid. Effective rooting depth is 10 to 50 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

The Shioya soil is very deep and excessively drained. It formed in water-deposited coral sand derived from coral reef formations. Typically, the surface layer is very dark gray loamy sand about 19 centimeters thick. Below this to a depth of 160 centimeters is very pale brown sand over limestone. Depth to porous limestone or cemented sand is more than 150 centimeters.

Permeability of the Shioya soil is rapid. Effective rooting depth is more than 150 centimeters. Available water capacity is low. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for subsistence farming, wildlife habitat, watershed, and urban and recreational development. It can be used for grazing.

This unit is unsuitable for commercial farming. It is limited by the areas of Takpochao Variant soil, which is very shallow, very cobbly, and droughty.

This unit is poorly suited to subsistence farming. It is limited by the areas of Takpochao Variant soil, which are very shallow, very cobbly, and droughty. The Shioya soil is droughty and has high salt content. Irrigation is necessary. Windbreaks are needed in areas facing the ocean.

This unit is poorly suited to grazing. The main limitation is droughtiness. Stocking rates can be adjusted to the amount of forage available.

This unit is moderately suited to urban development. It is limited mainly by the very shallow depth to bedrock in the Takpochao Variant soil. Excavation is difficult because of the bedrock. Excavations in the sandy Shioya soil are subject to caving. Septic tank absorption fields will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of beach areas as a result of seepage from onsite sewage disposal systems. There is a hazard of wave damage during typhoons along the coastal edge of this unit. A wide forested buffer strip can be maintained along the coastline.

This unit is moderately suited to recreational development. The main limitations are slope and the high content of gravel in the Takpochao Variant soil. Facilities can be constructed on the Shioya soil. There is a hazard of wave damage during typhoons along the coast.

The Takpochao Variant soil is in capability subclass VIIs, and the Shioya soil is in capability subclass IVs.

Prime Farmland

In this section, prime farmland is defined and discussed and the prime farmland soils in this survey area are listed.

Prime farmland is of major importance in providing the nation's short- and long-range needs for food and fiber. The acreage of high-quality farmland is limited, and the U.S. Department of Agriculture recognizes that government at local, state, and federal levels, as well as individuals, must encourage and facilitate the wise use of our nation's prime farmland.

Prime farmland soils, as defined by the U.S. Department of Agriculture, are soils that are best suited to producing food, seed, forage, fiber, and oilseed crops. Such soils have properties that are favorable for the economic production of sustained high yields of crops. The soils need only to be treated and managed using acceptable farming methods. Adequate moisture and a sufficiently long growing season are required. Prime farmland soils produce the highest yields with minimal inputs of energy and economic resources, and farming these soils results in the least damage to the environment.

Prime farmland soils may presently be in use as cropland, pasture, or woodland, or they may be in other uses. They either are used for producing food and fiber or are available for these uses. Urban or built-up land, public land, and water areas cannot be considered prime farmland. Urban or built-up land is any contiguous unit of land 10 hectares or more in size that is used for such purposes as housing, industrial, and commercial sites, sites for institutions or public buildings, small parks, golf courses, cemeteries, railroad yards, airports, sanitary landfills, sewage treatment plants, and water control structures. Public land is land not available for farming in national forests, national parks, military reservations, and state parks.

Prime farmland soils commonly get an adequate and dependable supply of moisture from precipitation or irrigation. Temperature and length of growing season are favorable, and level of acidity or alkalinity is acceptable. The soils have few, if any, rocks and are permeable to water and air. They are not excessively erodible or saturated with water for long periods and are not flooded during the growing season. The slope ranges mainly from 0 to 6 percent.

Soils that have a high water table, are subject to flooding, or are droughty may qualify as prime farmland soils if the limitations are overcome by drainage, flood control, or irrigation. Onsite evaluation is necessary to determine the effectiveness of corrective measures. More information on the criteria for prime farmland soils can be obtained at the local office of the Soil Conservation Service.

A recent trend in land use has been the conversion of prime farmland to urban and industrial uses. The loss of prime farmland to other uses puts pressure on lands that are less productive than prime farmland.

About 1,358 hectares, or nearly 4 percent, of the survey area would meet the requirements for prime farmland if an adequate and dependable supply of irrigation water were available.

The following map units meet the soil requirements for prime farmland when irrigated. On some soils included in the list, measures should be used to overcome a hazard or limitation, such as flooding, wetness, or droughtiness. The location of each map unit is shown on the detailed soil maps at the back of this publication. Soil qualities that affect use and management are described in the section "Detailed Soil Map Units." This list does not constitute a recommendation for a particular land use.

23	Dandan-Saipan clays, 0 to 5 percent slopes
26	Kagman clay, 0 to 5 percent slopes
43	Saipan clay, 0 to 5 percent slopes

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavioral characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as rangeland and woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

Crops

General management needed for crops is suggested in this section. The system of land capability classification used by the Soil Conservation Service is explained.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under "Detailed Soil Map Units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

The soils in the Northern Marianas are well suited to crop production; however, with a 1980 population of less than 15,000 people on Saipan and only 800 and 1,200 on Tinian and Rota, respectively, the local market for agricultural produce is limited. Guam is, at present, the only export market. Constraints to the export market include pest and disease problems, high transportation costs, and erratic produce supplies *(9)*. Production constraints include the availability of irrigation water, effective pest management, dissemination of modern agrotechnology, and farmer education. Rainy season conditions and periodic storms and typhoons have a disruptive effect on the consistency of production.

Traditionally, the Chamorros are an agricultural people. All families owned farms where cattle and pigs were raised and subsistence crops were grown. Corn was an important crop, as well as other subsistence crops. Carolinians are primarily a fishing people by tradition, although subsistence farming was also practiced on lands owned collectively by clans.

True commercial farming was instituted early in this century by the Germans. Coconut plantations were established, and copra was produced for export. Later, the Japanese transformed Saipan, Tinian, Aguijan, and Rota into vast sugarcane plantations; more than 12,000 hectares of land was in cane in 1938 *(7)*. Copra is no longer exported, and sugarcane is now grown commercially only on Tinian. The Japanese grew rice on the Mesei Variant soils in Susupe swamp on Saipan.

There is great diversity of agricultural systems in the Northern Marianas, ranging from traditional subsistence farming and gardening to modern commercial farming operations. Commonly, the distinction between subsistence farming and commercial farming is not

clear. Many farms that raise crops primarily for consumption by the extended family also market a part of some crops.

Perry *(9)* estimates that on Saipan about 80 hectares of land is in commercial farms and about 25 hectares is in subsistence farms. Commercial farms range from 1 to 6 hectares in size, and subsistence farms are less than 1 hectare. Tinian has the most extensive hectarage of commercial farms, with more than 100 hectares in small family farms and about 60 hectares in corporate farms. Most family farms are about 2 hectares in size. About 20 hectares on Tinian is in subsistence farms. On Rota, there are about 40 hectares of commercial farms and 20 hectares of subsistence farms. At present, there is no land in agricultural production on Aguijan. The total amount of land in crop production on Saipan, Tinian, and Rota is about 345 hectares. Not all hectarage, however, is under production at one time.

The types of commercial crops grown differ somewhat between the islands. A wide variety of crops are grown on Saipan. The main crops are cucumbers; melons, such as watermelon, cantaloup, and honeydew; varieties of green beans; tomatoes; bell peppers; taro; and onions. Other important vegetable crops include varieties of squash, eggplant, cabbage, radishes, and sweet potatoes. Fruit crops include bananas, papayas, avocadoes, citrus fruit, sweetsop, and soursop.

The cucurbit family encompasses the main crops of Tinian. They include watermelons, cucumbers, and honeydew melons and other muskmelons. Other important crops are tomatoes, bell peppers, taro, and onions. Milo and other field crops are grown for livestock feed on Tinian. The economic feasibility of growing sugarcane, sorghum, guava, and soursop for alcohol production is currently being investigated.

Commercial crops on Rota are primarily taro (fig. 6), sweet potatoes, hot peppers, yams, and bananas. Some bell peppers, cucumbers, and watermelons are also grown.

Subsistence farming is similar throughout the Northern Marianas. Taro, sweet potatoes, yams, cassava (tapioca), peppers, bittermelons, bananas, coconuts, mangoes, citrus fruit, and breadfruit are the main subsistence crops.

Commercial farmland on Saipan is mostly on Chacha, Chinen, Kagman, and Saipan soils. The single largest concentration of cropland is on the Kagman peninsula, where an agricultural irrigation system has been installed. On Tinian, most of the small commercial farms are in the Marpo Valley area, on Chinen and Dandan clays. Other farms are farther north on Banaderu, Chinen, Dandan, and Saipan soils. Farming on Rota is mostly on Luta soils. Some farmers work the lower plateaus during the rainy season and the higher, wetter Sabana region during the dry season.

Overall, the best agricultural soils in the Northern Marianas are the nearly level areas of Saipan soils on Saipan and Tinian. These deep, well drained soils have few limitations, although field access is often difficult during the rainy season. The moderately deep Dandan soils on Tinian are probably as productive as the Saipan soils for shallow-rooted vegetables. The deep Kagman soils are well suited to dry season agriculture. Because of slow permeability, these soils are excessively wet and thus are difficult to farm in the rainy season. Areas of Chacha soils that have been drained behave similarly to Kagman soils. During the rainy season, the few areas of Laolao soils that are nearly level have limitations similar to those of the Kagman soils; however, most areas of Laolao soils are sloping and thus are subject to erosion.

Most of the nearly level land on Saipan is underlain by the shallow Chinen soils. Chinen very gravelly sandy loam is covered by fill and therefore is not a good agricultural soil. Chinen clay, although shallow, can produce excellent vegetable crops if managed properly. Wetness during the rainy season generally is not a problem on these soils, but irrigation is necessary to sustain quality and yields of crops into the dry season. This is also true of the less extensive Banaderu soils. Deeper rooted crops such as bananas and tree fruit are much better suited to the deeper Saipan, Kagman, and Laolao soils. Field access during the rainy season is not so important for these crops, and the deeper rooting pattern helps to protect the plants from windthrow and moisture stress.

The plateaus of Tinian are dominated by Dandan and Chinen soils, which occur together in an intricate pattern. In some respects, these areas are better farmland than the areas of pure Chinen soils. Fewer limestone pinnacles are within the plow zone, and the overall water-holding capacity of the unit is higher; however, the restrictive areas of Chinen soils must be considered in field management. For instance, irrigation scheduling should be based on the droughty Chinen soils. Otherwise, crop performance will be uneven, with poor yields and quality in the spots of Chinen soils.

The very shallow Luta soils dominate the broad plateaus of Rota. These soils are very droughty; even brief periods without rain or irrigation can result in crop stress, which results in lower yields and quality. Luta soils in the Sabana area are significantly more moist and cool than Luta soils on the lower plateaus. Moist

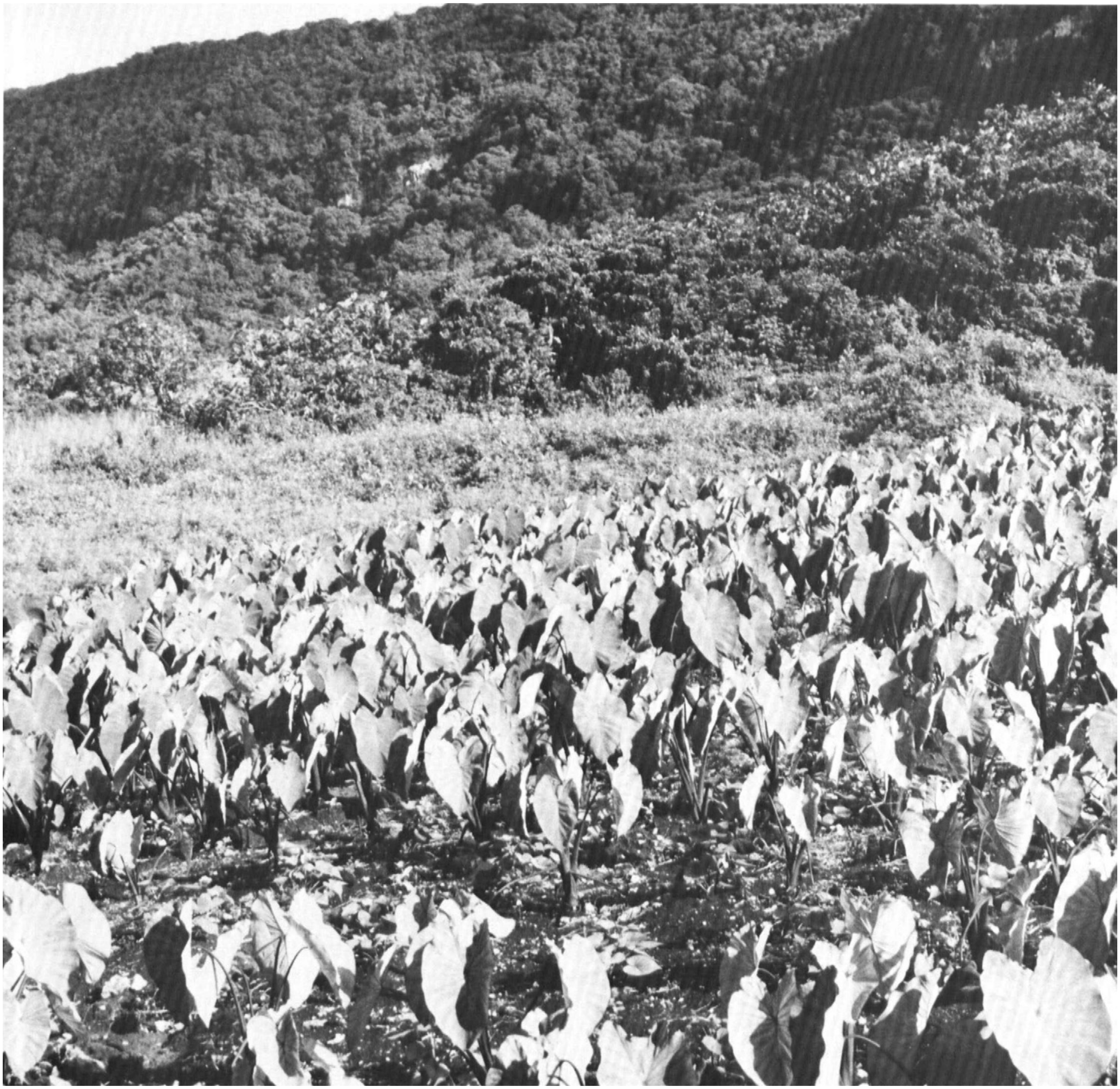

Figure 6.—Taro field in an area of Chinen clay on Rota. Forested Takpochao soils are in the background.

soils of the Luta series are mapped on the Sabana. These soils are better suited to dry season farming than are the Luta soils at lower elevations. The Chinen, Dandan, and Laolao soils in the Talakhaya area are

deeper and have a higher water-holding capacity than the Luta soils; however, most of this area is sloping and is difficult to manage in the rainy season. This is the best area on the island for fruit crops.

Production of crops in the survey area is limited mainly by climatic factors, shallow soil depth, hazard of erosion, wetness, and low soil fertility. These limitations are discussed in the following paragraphs.

Climate.—The climatic limitations for crop production include excessive precipitation in the rainy season, a moisture deficit in the dry season, and periodic storms and typhoons.

Vegetable production drops dramatically in the rainy season. For many crops the frequent rains interfere with fruit set and increase susceptibility of the plants to disease. Ponding and excessive wetness cause difficulties in field access on many soils. For this reason the slowly permeable Kagman and Chacha soils are difficult to manage during the rainy season. Tillage equipment can become bogged in the sticky clay that is characteristic of these soils, and its use results in the formation of a tillage pan. Field operations should be avoided following heavy rains. Grassed waterways and field ditches can be used to remove excess water. Raised beds can be used to avoid root rot and improve yields on these soils. Other soils that have moderate permeability are better suited to intensive rainy season crop production.

The severity of the dry season moisture deficit is related to the moisture requirements of the crop and the available water capacity of the soil. Chacha, Kagman, and Saipan soils have the highest available water capacity of the agricultural soils in the Northern Marianas. Dandan and Laolao soils have lower available water capacity. Banaderu, Chinen, and Shioya soils have low available water capacity, which limits their use for dryland farming. Luta soils have very low available water capacity.

Irrigation can be used to overcome the dry season moisture deficit. The frequency of irrigation and the amount of water applied should be carefully adjusted to the soil and crop characteristics. For example, soils that have low available water capacity require light and frequent applications of irrigation water. Luta soils are so droughty that even short dry periods in the rainy season can cause moisture stress in some crops. Overirrigation on any soil wastes water and leaches fertilizer out of the root zone. The crop characteristics are also important in scheduling irrigation. Even on the deep Kagman and Saipan soils, young or shallow-rooted crops can suffer moisture stress because these crops cannot use the deep moisture reserves in these soils.

For most vegetable crops drip irrigation is the most appropriate system to use. Drip irrigation allows for the light, frequent irrigations necessary on the droughty soils and on young crops. Drip systems operate at the low water pressure that is common in the survey area. Unlike sprinkler systems, drip irrigation is unaffected by the strong dry season trade winds, and they will not damage crops by placing water on leaves, flowers, and fruit. Weeds are not so much of a problem with drip systems as with other irrigation systems. This is because water is applied only around the individual plants and not in the intercrop rows and spaces.

There are several common management problems with drip systems in the Northern Marianas. Low quality water can result in emitters becoming clogged. During the dry season, rats often chew through the tubes in search of water. Effective filtration systems and periodic flushing with chemicals can reduce clogging problems. A rat control program is needed.

Fruit trees and banana plants also respond to irrigation, even on the deep soils. Irrigation is important for establishment of new orchards. When mature, these crops can survive and grow on deep soils without irrigation, but yield and quality of the fruit are higher if irrigation is used. The Chacha and Kagman clays have high shrink-swell potential, and they commonly develop wide cracks when dry. This shrinking and cracking action can sever the roots of fruit trees. Irrigation prevents soil cracking. Drip systems can be used in orchards and plantations. Low pressure sprinklers are also effective.

Irrigation improves yields of forage and field crops during the dry season, but the economics of irrigating these crops must be studied. Yield response is related to the available water capacity and fertility of the soil. High pressure sprinkler systems are most appropriate for field and forage crops.

Trade winds greatly increase the water demands of crops. Field windbreaks reduce the amount of irrigation water needed for crops and reduce the physical damage to them. Design of windbreaks and species suitable for use in them are discussed in the "Windbreaks" section of this survey.

The hazard of storm and typhoon damage is difficult to guard against, and it can have a disastrous effect on the consistency of market supply. Field windbreaks help to protect against strong trade winds but are not effective during typhoons. Farmers can protect themselves against complete loss of annual income by

growing some typhoon resistant crops such as taro and onion and by staggering their planting dates so as to produce continuously and consistently; thus, a single typhoon event would lower yearly income but would not obliterate it. The statistical probability of a typhoon event is higher in the rainy season. Higher prices or reduced production, or both, help to compensate for the higher risks of production during this period.

Shallow soil depth.—Three of the major agricultural soils in the Northern Marianas are shallow or very shallow to limestone. These soils are those of the Chinen, Banaderu, and Luta series. The main effects of shallow soil depth on agriculture are droughtiness, as previously discussed; mechanical interference with tillage; mechanical mixing of limestone material into the soil; and restriction of roots.

Depth to limestone in the Banaderu and Chinen soils generally is 25 to 50 centimeters, which is below the depth of normal cultivation; however, pinnacles of limestone extend above this depth and thus will interfere with cultivation. The Luta soils are dominantly 10 to 25 centimeters deep to limestone, which is well within the depth of normal cultivation (fig. 7). Tillage equipment can be used that rides across the top of the limestone contact without damaging the equipment and without breaking off chunks of limestone. Such equipment includes the disk plow, the disk, and the springtooth harrow.

Plows are difficult to use in these soils, and their use breaks off chunks of limestone and mixes them into the soil. These limestone fragments will interfere with tillage. A mechanized rock picker can be used to remove these cobbles, but many farmers remove them by hand. In some cases, it is desirable to remove small rock outcroppings and very shallow pinnacles to create more uniform soil depth in a field. A subsoiler can be used to shatter and dislodge these outcroppings, which then can be removed from the field.

In areas where the limestone is soft, such as in certain areas of the Luta soils, excessive and deep cultivation will pulverize the limestone and mix it into the soil as sand-sized particles. This may cause some micronutrients to become unavailable to the crop.

Shallow soil depth can restrict the root development of the crop. This is not a serious problem for shallow-rooted, annual vegetable crops, as long as water and nutrients are available in the shallow root zone. Root crops, fruit trees, and banana plants have restricted rooting patterns in these shallow or very shallow soils. The shallow rooting pattern does not provide good mechanical support, and trees are susceptible to windthrow. It is possible to excavate holes in the limestone and backfill with soil material before planting fruit trees or banana plants. Banaderu and Chinen soils have small pockets that are deeper to limestone; these pockets can be used for tree crops.

Hazard of erosion.—Erosion can seriously reduce the productivity of soils. Most of the fertility of the soils in this survey area is in their dark-colored surface layer, which generally is about 15 to 20 centimeters thick. If the infertile subsoil is exposed, crop yields will be reduced, even with increased use of fertilizer. The potential for erosion is related to various factors, including steepness and length of slope, surface cover, and crop management factors.

This soil survey uses slope to separate soil map units. Soils that have slopes of less than 5 percent are subject to only a slight hazard of erosion, but erosion control systems may be needed. Soils that have slopes of 5 to 15 percent are subject to a moderate hazard of erosion. These soils can be farmed successfully over several years only by using erosion control systems. Soils that have slopes of 15 to 30 percent are subject to a severe hazard of erosion and therefore should be maintained in permanent plant cover. Orchards can be planted on these soils, but cultivation should be avoided. Farming is not practical where slopes are more than 30 percent.

One of the simplest and easiest erosion control practices is cross-slope farming, which should be practiced on even the most gentle slopes. Diversions and grassed waterways can be used to channel runoff water and prevent gully erosion. Stripcropping shortens the slope length and traps sediment before it moves off the field. Terraces or hillside ditches can be constructed on sloping, deep soils.

Wetness.—Excessive wetness affects some soils in the Northern Marianas. Mesei Variant soils, which are in Susupe swamp and other places, have a permanent high water table. Most crops cannot be grown in these soils without artificial drainage. Inarajan soils have a high water table during the rainy season. These soils are suitable for dry season farming, but drainage is needed during the rainy season. Chacha soils have a seasonal high water table in their natural state, but most areas have been artificially drained. On Saipan, Chacha soils on the Kagman Peninsula have been drained with a series of surface ditches. On Tinian, the water table of the Chacha soils has probably been lowered by pumping from the Makpo wells. Chacha and Kagman soils are limited by wetness during the rainy season because of slow permeability. Raised beds, diversions, and field ditches help to overcome this limitation.

Figure 7.—Area of Luta cobbly clay loam that is very shallow over limestone. Many of the cobbles visible between the rows of sweet potatoes were probably broken out of the underlying limestone.

Certain crops are adapted to or require soil wetness. Mesei Variant and Inarajan soils, for example, are well suited to wetland taro and rice production. The slow permeability of the Chacha, Kagman, and Inarajan soils makes them well suited to the establishment of aquaculture ponds.

Fertility.—The native fertility in the soils of the Northern Marianas is not adequate for sustained high

yields of commercial crops or of most subsistence crops. Fertilization is not necessary for certain subsistence tree crops such as coconut and breadfruit, but many traditionally nonfertilized crops such as mango would benefit from a fertilization program. Continuous cropping without some form of fertilization inevitably leads to declining crop yields.

Organic matter is an important source not only of crop nutrients but of nutrient-holding capacity. Organic matter decomposes quickly under cultivated conditions in this tropical climate, releasing nutrients in the process. Proper management practices will replenish the soil's organic matter. One method is to allow the field to lie fallow and grow back with grasses and forbs. These plants can be disked into the soil. A cover crop can be grown for the same purpose. The advantages of a cover crop over fallow are that no weed seeds are produced and that, if a legume is used in the cover crop, additional nitrogen is fixed and added to the soil. Careful clearing of land, prevention of erosion, turning under crop residue, and rotation of crops with pasture are all techniques that can maintain adequate levels of organic matter. Compost can be made and used by subsistence farmers.

In addition to maintenance of organic matter content, commercial inorganic fertilizer is used in most commercial farming operations. Generally, a balanced fertilizer with nitrogen, phosphorus, and potassium should be used; however, the exact amounts of each can be quite variable, depending on such factors as the cropping history of the field, the crop to be grown, and the kind of soil.

Nitrogen fertilizer is quickly leached out of the soil, particularly in the shallow Banaderu, Chinen, and Luta soils. Split applications of nitrogen are necessary, with one or more applications as a sidedressing during the period of crop growth. A fertilizer with ammonium as the nitrogen source is suitable for these shallow, mildly alkaline soils, because ammonium has an acidifying effect.

Most soils in the Northern Marianas are initially low in content of phosphorus, and they tend to "fix" about a quarter to a third of added phosphorus, releasing it slowly over time. For this reason, and because phosphorus does not move in the soil as does nitrogen, phosphorus should be banded directly into the root zone.

Cultivation of the shallow Banaderu, Chinen, and Luta soils mixes limestone into the root zone. Because of this, the soils are saturated with calcium carbonate and some crops may show deficiencies of such micronutrients as zinc and iron. Tomatoes, bell peppers, and other crops grown on these soils may respond to foliar micronutrient sprays.

Animal manure is traditionally used as fertilizer, and it can be effective if properly managed; however, nitrogen can be quickly volatilized and lost as ammonia gas from manure. The resulting low-nitrogen manure can tie up soil nitrogen and actually cause a nitrogen deficiency in the crop. Both manure and cover crops should be turned under early to allow for decomposition before the crop is planted. Unlike inorganic fertilizer, manure adds organic matter to the soil.

In subsistence farming, commercial fertilizer, pesticides, and machinery generally are not used; however, certain labor intensive techniques that are impractical for commercial operations can be used.

Intensive organic matter management is practical for subsistence farming. Weeds, crop residue, slash from surrounding vegetation, and animal manure can be mixed into compost and used as fertilizer. Composting is crucial on plots where inorganic fertilizer is not used.

Mulching is also important on a subsistence plot *(11)*. Mulch conserves moisture, helps to control erosion in sloping areas, and prevents the soil surface from becoming excessively hot and dry. As the mulch decomposes, it adds nutrients to the soil. Slash from tangantangan is a good source of nitrogen if used in this manner; however, tangantangan inhibits seed germination *(12)* and therefore should be used only around established plants.

Subsistence plots can be established on soils that are too steep for commercial farming; however, clean cultivation should be avoided in these areas. Weeds around plants can be controlled by hand pulling and mulching. Undergrowth between plants or on plot borders can be controlled by mowing or slashing. Small terraces and embankments can be built by hand with the use of locally available materials.

Assistance for both subsistence and commercial farmers is available from the local office of the Soil Conservation Service. This office can help with farm planning, irrigation design, erosion control, and other practices that help farmers make the best use of their land. Assistance involving crop production practices such as selecting crop varieties, fertilizers, and disease control techniques is available from the Division of Plant Industry and Extension Service of the Department of Natural Resources, Commonwealth of the Northern Mariana Islands.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

In the capability system, soils generally are grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w*, *s*, or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

The hectarage of soils in each capability class and subclass is shown in table 2. The capability classification of each map unit is given in the section "Detailed Soil Map Units."

Grazing Land

Grazing is an important land use in the survey area. About 6,800 hectares, or one-fifth, of the land in the area is classified as either pastureland or rangeland *(9)*. This includes roughly 8 percent of Saipan, 43 percent of Tinian, 44 percent of Aguijan, and 6 percent of Rota. Only Tinian has pastureland, and it totals 4,420 hectares; the balance of the grazing land is rangeland, which includes grazed woodland and all grazeable savannah lands. Much of the rangeland is not grazed. For instance, Aguijan has no domesticated livestock, and grazing is not presently permitted in the Sabana area on Rota. Individual ranches generally range from 20 to 200 hectares, with the notable exception of the 4,050-hectare Bar-K Ranch on Tinian.

Rangeland in the Northern Marianas can be roughly divided into three types: (1) grazed woodland, (2) savannah dominated by swordgrass, and (3) savannah dominated by introduced grasses and forbs.

All plant names used in this section are listed in figure 8 by scientific name and by common names in English and Chamorro *(5)*.

Grazed woodland.—Grazed woodland on Saipan and Tinian generally is dominated by tangantangan trees, which commonly grow on the Chinen, Dandan, and Saipan soils. On Rota the woodland commonly is a mix of introduced trees including gagu, sosigi, atbot det fuego, niyok, and kalaskas, which grow mainly on the Luta soils.

The carrying capacity of the grazed woodland varies depending on factors such as the degree of canopy closure and the nature of the understory, but it generally is quite low. Tangantangan foliage is grazed where accessible, but in most places the foliage is well out of reach of cattle.

Figure 8.—List of scientific and common plant names

Scientific name	Common name: English	Common name: Chamorro
Trees:		
Acacia auriculaeformis	sickleleaf acacia	none
Acacia confusa	Formosan koa	sosigi
Acacia mangium	broadleaved acacia	none
Albizia lebbeck	white monkeypod	kalaskas
Annona muricata	soursop	laguanaha
Artocarpus altilis	breadfruit	lemmai
Artocarpus mariannensis	breadfruit	dokdok
Barringtonia asiatica	fish-kill tree	puting
Calophyllum inophyllum	Alexandrian laurel	da'ok
Cananga odorata	ylang-ylang	ilangilang
Carica papaya	papaya	papaya
Casuarina cunninghamiana	smallcone ironwood	none
Casuarina equisetifolia	horsetail casuarina	gagu
Cocos nucifera	coconut	niyok
Cynometra ramiflora	none	gulos
Delonix regia	flame tree	atbot det fuego
Elaeocarpus joga	none	yogga'
Erythrina variegata	coral tree	gaogao
Eucalyptus camaldulensis	Eucalyptus	none
Eugenia uniflora	Surinam cherry	pitanga
Ficus prolixa carolinensis	banyan	nunu
Ficus tinctoria	strangling fig	hoda
Guamia mariannae	none	paipai
Guettarda speciosa	none	panao
Hernandia sonora	none	nonak
Hibiscus tiliaceus	sea hibiscus	pagu
Intsia bijuga	ifil	ifit
Leucaena leucocephala	none	tangantangan
Leucaena leucocephala cultivar	giant tangantangan	none
Mangifera indica	mango	mangga
Merilliodendron megacarpum	none	faniok
Morinda cirtifolia	Indian mulberry	ladda
Neisosperma oppositifolia	none	fago'
Pandanus dubius	screw pine	pahong
Pandanus fragrans	screw pine	kafo'
Phyllanthus acidus	Tahitian gooseberry	ibba'
Pisonia grandis	none	umumu
Pithecellobium saman	monkeypod	none
Pterocarpus indicus	none	narra
Serianthes Nelsonii	none	trongkon guafi
Swietenia macrophylla	Honduras mahogany	none
Tectona grandis	teak	none
Thespesia populnea	none	binalo
Tournefortia argentia	none	hunek
Ximenia americana	sour plum	pi'ot
Shrubs:		
Cestrum diurnum	none	tintanchina
Glochidion marianum	glochidion	chosgo
Pemphis acidula	pemphis	nigas
Psidium guajava	guava	abas
Triphasia trifolia	none	lemonchina

Figure 8.—List of scientific and common plant names—Continued

Scientific name	Common name	
	English	Chamorro
Grasses and forbs:		
Bidens alba	beggartick	none
Brachiaria mutica	paragrass	none
Calopogonium mucunoides	none	calopo
Centrosema pubescens	centro	none
Conyza canadensis	horseweed fleabane	none
Desmondium intortum	desmodium	none
Desmondium uncinatum	Spanish clover	none
Dolichos hosei	Sarawakbean	none
Dolichos lablab	lablab	none
Eupatorium odoratum	none	masiksik
Gleichenia linearis	false stagehorn fern	mana
Hyptis capitata	buttonweed	none
Lantana camara	lantana	none
Mikania scandens	none	none
Mimosa invisa	mimosa	none
Miscanthus floridulus	swordgrass	netti
Momordica charantia	bittermelon	none
Nephrolepis hirsutula	none	galak
Panicum maximum	guineagrass	none
Pennisetum polystachyon	foxtail	none
Pennisetum purpureum	napiergrass	none
Phragmites karka	common reed	karisu
Polypodium scolopendria	none	kahlao
Spathoglottis plicata	ground orchid	none
Stachytarpheta jamaicensis	false verbena	none

Savannah dominated by swordgrass.—This type of rangeland is the characteristic of the Akina soils on Saipan and Rota. Agfayan Variant and Laolao soils have a swordgrass cover in places, and on Saipan extensive areas of Chinen and Takpochao soils are in swordgrass. Only one very small area of swordgrass has been observed on Tinian, and none is known on Aguijan. Swordgrass is best expressed on the acidic, infertile Akina soils, where it forms thick, almost pure stands as much as 2 meters high. These stands are interrupted by scattered badland scars and associated pioneer species such as manafern. Occasional gagu trees are present. In other places the swordgrass is interspersed with foxtail, mimosa, buttonweed, ground orchid, and false verbena. Shrubs and low trees are common, particularly where the savannah grades into forest.

This swordgrass savannah has a very low carrying capacity for livestock because the swordgrass is unpalatable and is grazed only as a last resort. Foxtail has value as forage when young, but it becomes nutritionally very poor as it matures. Most of the other species are unpalatable forbs.

Savannah dominated by introduced grasses and forbs.—This type of rangeland supports a wide variety of grass and forb plant communities. The soils in these areas include those of the Chinen, Dandan, Kagman, and Saipan series, as well as those of the Luta series on Rota. Some areas, such as the Sabana area on Rota, support thick stands of napiergrass and guineagrass. Foxtail is dominant in some areas, commonly mixed with mimosa, beggartick, galak, and others. A forb community dominated by galak, ground orchid, kahlao, Mikania scandens, and other species occurs on the Sabana as well.

The grass-dominated communities can grade into forb communities because of present or past management practices. At present, the main species on these disturbed lands is masiksik. A host of other invasive or pioneering plants are present, including mimosa, bittermelon, beggartick, galak, Conyza canadensis, lantana, and various dryland sedges. Of

Figure 9.—Guineagrass pastures on Chinen and Dandan soils on Tinian. Saipan in background.

the grasses, foxtail is the most common component of these forb communities.

The guineagrass and napiergrass rangelands provide excellent grazing opportunities. Without proper grazing management, however, these grasslands will be converted to forb communities, probably dominated by the unpalatable masiksik. The forb communities have very low carrying capacities.

Pastureland.—At present, the only pastures on the islands are those of the Bar-K Ranch on Tinian. These pastures are planted as 100 percent guineagrass (fig. 9). Less desirable grasses and forbs are controlled with herbicides.

Poor management has contributed to the generally poor condition of the rangelands on the islands as well as the relatively low animal weight gains per hectare. Continuous grazing, understocking, and lack of stock water are the main management problems. Continuous grazing depletes the reserves of the desirable species and allows the unpalatable weeds to crowd them out.

Figure 10.—An area of Luta soils covered by masiksik, an undesirable weed.

Understocking causes uneven, selective grazing and allows forage to mature. Tropical forage is of extremely poor quality when mature.

Rotation grazing is a system wherein an area is heavily stocked and grazed for a relatively short period of time and then is allowed to rest and regrow. The high stocking rate forces the cattle to eat everything, not just the most palatable plants. Undesirable plants are trampled because of the high stocking rate. The rest period allows the plants to recuperate. Grasses generally regrow faster than less desirable forbs and shrubs, so the condition of the range is improved. Cross-fencing is used to establish management units of appropriate size.

Animals must have access to mineral blocks and stock water. A grazing cow needs about 10 to 15 gallons of water per day. The location of stock water and mineral blocks can be used to control grazing patterns as well.

Mowing can be used to cut overmature forage and control weeds. Herbicides can also be used to control weeds, particularly if wick applicators are used.

Dragging spreads manure more evenly and promotes uniform growth. Fertilization is also important, but the kind and amount of fertilizer to be used depend on the kind of soil, the type of pasture, and the economics of animal production at the time.

Low quality of forage is a major limitation to livestock production in the Northern Marianas. The native savannah areas are dominated by the unpalatable swordgrass, and palatable forage in woodland areas is also very low. Most of the rangeland that is dominated by introduced species also produces forage of low quality. At present, a biological control is being developed to check the rampant spread of masiksik (fig. 10); however, the masiksik will merely be replaced by another noxious weed if proper management practices are not introduced. Intensive rotation grazing improves the carrying capacity of these lands. After intensive grazing management has been established, other forage improvement practices can be applied.

A major limitation in areas of grazed woodland is the degree of canopy closure, which affects the amount of sunlight reaching the understory. The forest can be thinned, leaving some large spreading trees for livestock shade. Strip clearings can be established in tangantangan forests. Cleared areas can then be prepared for planting with adapted grasses and legumes. The available forage from tangantangan can be increased by cutting the stem at about 50 centimeters and periodically grazing the abundant shoot growth. Overmature stands can also be chained down or cut with a rollerchop machine and allowed to resprout. At present, an insect pest seriously limits tangantangan forage production.

The simplest method of forage improvement on intensively grazed savannah is to oversow the range with adapted grass and legume seed and to permit the seed to be trampled into the ground. More intensive techniques involve destroying the existing vegetation, preparing a seedbed, and planting improved grasses and legumes. Disking is the best method of destroying the undesirable range species, because it incorporates organic matter into the soil. If the vegetation is coarse or woody, prescribed burning can be used. When resprouting of the undesirable species occurs, herbicides can be used to kill them. The area can then be prepared and sown with improved grasses and legumes.

On soils that are not seriously limited by acidity or wetness, suitable grass species for introduction are napiergrass or guineagrass. Suitable legumes for introduction include calopo, centro, Sarawakbean, lablab, silverleaf, and greenleaf desmodium. Once the legume is well established in the stand, the grass-legume mixture will not require nitrogen fertilization. The legume will fix atmospheric nitrogen in sufficient quantity to supply the needs of the grass; however, modest annual applications of phosphorus are needed *(11)*.

Higher production can be attained with pure grass pastures than with grass-legume pastures; however, this requires fertilization rates of at least 200 kilograms of nitrogen per hectare per year. If the forage is used as greenchop and the animals are fed off-site, this rate should be doubled. Pastures should be fertilized after every grazing cycle. Irrigation is needed during the dry season. This type of capital- and labor-intensive management is probably not economical on a large scale in the Northern Marianas.

Many areas in the Northern Marianas are poorly suited or not suited to grazing, even though some are in native savannah and thus are classified as rangeland. Soils that have slopes of 30 percent are poorly suited to cattle grazing. Careful fence placement prevents animals from using only ridgelines or valleys. Livestock trails are susceptible to gully erosion.

Several detailed soil map units include extensive areas of Rock outcrop, which limits the suitability for grazing. Takpochao soils are so rough that walking on them is difficult. Banaderu, Chinen, and Luta soils all include a Rock outcrop component. Most areas of these soils are in native or secondary forest and support virtually no useable forage. Forage improvement is not feasible, so these soils are not suitable for grazing.

Akina, Chinen, and Laolao soils in some areas have slopes of 15 to 30 percent. Rangeland management is possible on these units, but it is limited by the slope. Seedbed preparation for forage improvement is not feasible, although oversowing can be practiced along with intensive grazing. Gully erosion can occur along livestock trails if rotation grazing is not practiced.

Mesei Variant and Inarajan soils are limited by wetness. Mesei Variant soils have a permanent high water table, and the existing karisu vegetation on them has no value as forage. Inarajan soils are seasonally wet; stock should be removed when the soils are ponded. In places, the Inarajan soils support stands of the highly palatable paragrass. Paragrass and legumes such as centro and greenleaf desmodium can be used for pasture improvement on these soils.

Most of the soils that have slopes of less than 15 percent are well suited to grazing; however, management limitations do exist. Luta soils are very shallow and droughty and therefore are only moderately suited to grazing. Map units that include the Banaderu,

Chinen, or Luta soils commonly have occasional cobbles on the surface and small areas of Rock outcrop, which can damage mowing equipment. Chacha, Kagman, and Laolao soils are saturated with water at times during the rainy season. Unsurfaced ranch roads become muddy and slick. Access to and management of grazing areas may be difficult at these times.

There is a hazard of erosion during pasture establishment even on gently sloping soils. Seedbed preparation should be on the contour.

A major limitation to forage production on all the soils in the survey area is the moisture deficit during the dry season. This moisture limitation is most severe on the soils, such as those of the Banaderu, Chinen, Luta, and Shioya series, that have low available water capacity. Irrigation would correct this problem, but the economics of pasture irrigation on the islands is questionable; thus, ranchers face the problem of cyclic forage production with constant animal feed requirements. Either the range is underused during the rainy season or the stock is stressed during the dry season.

Various management techniques can be used to overcome this problem. During high forage growth periods, the less efficient continuous grazing system can be used. As forage growth slows, rotation grazing can be used. Another possibility is to make silage during high growth periods. Simple, inexpensive silage techniques can be used. Herd management techniques, such as decreasing herd size and adjusting the weaning period, can be used to adjust the grazing demand to the available forage. Another possibility is to intensively manage a small area of the best soils during the dry season. These areas can be planted to grass, fertilized, and irrigated during the dry season. As forage quality declines on the extensively managed part of the ranch, this intensively managed area can be used *(11)*. The deep Kagman and Saipan soils are best suited to intensive pasture management.

Assistance in ranch planning, range and pasture seeding, erosion control, and water management, including pond construction, is available at the local office of the Soil Conservation Service. Assistance with livestock production, such as selecting livestock varieties, feed, disease control, and marketing, can be obtained from the Division of Animal Industry and Animal Health, Department of Natural Resources, Commonwealth of the Northern Mariana Islands.

Forest Land

About 70 percent of the survey area is forested. Saipan is 78 percent forest, Tinian is 48 percent, Aguijan is 56 percent, and Rota is 88 percent *(14)*. A long history of island settlement combined with more recent urbanization, fire, agricultural development, and World War II have all contributed to altering the forests and reducing their extent. This section discusses the different types of forest, the limitations to forest growth, and various forest uses and reforestation techniques.

The characteristics of the forests in the Northern Marianas vary from place to place because of such factors as kind of soil, topographic position, degree of past disturbance, and seed source. A general division is made here between forests dominated by native trees (native forests) and forests dominated by introduced, exotic species (secondary forests); however, a few introduced species commonly are present in the native forests, and vice versa. The brief descriptions that follow give only a few of the most common species. For a more complete listing of forest species, see figure 8, page 65.

In the following paragraphs native forests and secondary forests in the survey area are described and limitations to forest growth are discussed.

Native forests.—The extent of native forests has been greatly reduced as a result of past agricultural efforts. For instance, much of Tinian has been deforested for well over 200 years *(5)* and has been replaced with secondary forests. Virtually all remaining native forests are on soils that are unsuitable for farming, such as Takpochao and Luta soils that are associated with Rock outcrop. In fact, the presence of native forests proved to be a reliable indicator of these map units during fieldwork for this soil survey. No good estimate is available for the present extent of native forests. If the extent of the previously mentioned map units is used as a rough estimate, then 19 percent of Saipan, 13 percent of Tinian, 55 percent of Aguijan, and 41 percent of Rota, or 23 percent of the total survey area, is in native forests.

A typical forest has a closed canopy and is characterized by relatively few understory species. Larger trees are buttressed, with many epiphytes in the upper branches. Epiphytes generally increase with elevation. Height varies with exposure, but trees seldom exceed about 30 meters. Typical native trees include yogga', dokdok, nunu, umumu, gulos, paipai, ifit, pahong, kafo', panao, nonak, fago, and hoda.

The large trees (yogga', dokdok, nunu, umumu) commonly grow as scattered individuals, and the smaller ones (paipai, gulos, and pahong) fill in around and beneath them. In many areas the large individuals are few or absent, which results in stands of almost

Figure 11.—Extensive forests of tangantangan on Chinen soils on Saipan.

pure gulos or paipai. Different trees are dominant in different places. For instance, large areas on Saipan are dominantly gulos. Kafo' becomes dominant at high elevations and near the coast. A native strandline forest is best expressed on the Shioya and Takpochao Variant soils on Rota. Nonak is dominant, with puting, kafo', and, on the ocean edge, hunek.

A small area of native forest dominated by faniok on Rota is related to the associated kind of soil. Volcanic soils are in pockets on a limestone slope, which causes percolating ground water to surface. The presence of this water favors the establishment of faniok.

One rare and endangered tree species occurs in the native forests on Rota, the *Heritiera longipetiola*. Another tree, trongkon guafi, is being considered for rare and endangered species status. Areas where these trees grow should be identified and protected.

Wetland forest is not extensive in the Northern Marianas. A few small forests of pagu occur on Mesei Variant soils, and a mangrove stand extends from American Memorial Park to Lower Base on Saipan.

Secondary forests.—The most common secondary forest on Saipan and Tinian is one dominated by tangantangan (fig. 11). Following the devastation of World War II, the United States military aerially broadcast tangantangan seed over the landscape. Today, most of the old cane fields and military facilities are covered by tangantangan forest. Tangantangan is

Figure 12.—A forest dominated by sosigi on Chinen soils on Saipan. Chacha soils in foreground, and Takpochao soils along limestone cliffs in background.

not abundant on Rota and Aguijan, although occasional stands are present.

Tangantangan generally is absent on Akina and Agfayan Variant soils. This is attributable to the low calcium, high soluble aluminum conditions in the Akina soils, but reasons for its absence on Agfayan Variant soils are not clear. Tangantangan forests are not managed for wood production, and thinning to about a 1-meter spacing would increase the size of the trees. After a pole is cut, the stump resprouts, which is called coppicing. Regrowth can be improved by allowing the dominant shoot to grow and pruning the others.

There are other important secondary forest trees, commonly occurring in mixed stands with tangantangan. These include sosigi, kalaskas, gagu, gaogao, monkeypod, and atbot det fuego. Sosigi is dominant in many areas of Saipan (fig. 12) and on the Laolao soils on Tinian and Rota. Gagu forests commonly can be related to windbreaks in the old sugarcane fields, and atbot det fuego commonly surrounds old house and village sites.

Another important secondary forest is agroforest, consisting of naturalized, food-bearing trees. Such trees include niyok, mangga, lemmai, lemonchina, and

papaya. This agroforest commonly grades into native forest, particularly strand forest, and into other secondary forest types. Management generally is limited to maintaining access trails and, in places, cutting out competing trees.

Limitations to forest growth.—The height of many tree species in the Northern Marianas is effectively controlled by frequent typhoons, which snap the tops of the tallest trees. Many trees, particularly those on the very shallow Luta and Takpochao soils, are uprooted and toppled during typhoons. The native forest has been called a "typhoon forest" *(13)* to denote this important limitation to forest growth.

The trade winds blow from the east and northeast. As a result, coastal areas that have east and northeast exposures are subject to salt spray and buffeting winds. These conditions restrict forest growth and have resulted in a belt of coastal shrubland that is dominated by such species as nigas. Most of these areas are in a Takpochao-Rock outcrop complex. A strand forest located directly inland from the nigas shrubland is probably limited to species that can withstand salinity and high winds.

Trees on exposed ridgelines, hilltops, and high, open plateaus are more subject to storm and typhoon damage than are trees on sheltered slopes and in valleys. Native vegetation on windward ridgelines commonly is stunted, and high winds are responsible for the stunted forests in the Sabana area of Rota. The largest trees commonly are on north- and west-facing slopes and in valleys. Forest plantations should be established in low-lying, sheltered areas.

Soil depth affects both rooting depth and available water capacity, although these relationships are not so clear for trees as they are for annual crops. Roots of native trees commonly penetrate the limestone underlying the Banaderu, Chinen, Luta, and Takpochao soils. Many native trees grow directly in areas of limestone Rock outcrop, and their major roots are exposed at the surface. Native trees are well adapted to the prolonged moisture deficit on these droughty soils during the dry season. One would expect better production on deeper soils such as those of the Dandan, Kagman, and Saipan series, but there is no evidence to support this. Virtually all areas of deep soils have been cleared, and there is presently no native forest on the deep soils of the Northern Marianas. Forest plantations, which use fast-growing introduced species, are limited by the windthrow hazard and low available water capacity of the shallow soils.

The vegetation on the Akina soils on Saipan and Rota is savannah dominated by swordgrass. It is possible that trees once grew in these areas, but reforestation experience on Guam indicates that most trees grow very poorly on the Akina soils. The main reason seems to be the low content of calcium and high content of soluble aluminum in these soils. The low reaction, or acidity, of the Akina soils is an indicator of these adverse chemical conditions. The Laolao soils are also volcanic soils; in places they are acidic, but they are much higher in bases such as calcium. These soils support forest growth. There are no native forests on Laolao soils, however, and it is not known what the native vegetation was on these soils. Forest plantations should not be located on Akina soils unless reforestation is the purpose for the plantation. Laolao soils, however, seem well suited to forest growth.

Fire perpetuates the presence of savannah at the expense of the forest. Even the calcium-poor Akina soils would probably develop a forest vegetation type if fires did not kill invading shrub and tree seedlings. There are large areas of Chinen soils south of Mount Takpochao on Saipan that are in swordgrass savannah. These areas frequently burn during the dry season. If fire were excluded, these areas would revert to forest. Prescribed burning can be a useful tool for clearing or managing land, but wildfire can quickly destroy a young forest plantation. Firebreaks, created by clearing and maintaining borders around new plantations, can be used to protect trees. Fires in mature forests do not occur in the Northern Marianas because of the lack of dry, burnable material on the ground.

A high water table prevents trees from growing in most areas of the Mesei Variant soils. Trees grown on Inarajan soils and in some areas of Chacha soils must be adapted to a seasonal high water table.

Forests in the Northern Marianas are used primarily for recreation, hunting, and food gathering and as a source of firewood and medicinal and handicraft material. The preferred firewood species is tangantangan. Important food species include niyok, lemmai, mangga, a variety of citrus, and many others. Suruhanos, or traditional healers, are active and important in the islands, and they use many species of forest plants. Handicraft and traditional uses include weaving of baskets and hats from pandanus and coconut leaves, cutting of thatch and poles for temporary shelters, carving of wood for furniture and curios, and harvesting of ilangilang and plumeria flowers for marmar headbands.

Potential for commercial lumber production in the Northern Marianas is low. Existing forests are composed of a few species suitable for lumber. Of these, few are of sufficient size and quality for

commercial use. The height of plantation grown trees is restricted by frequent typhoons. Water deficits during the dry season may restrict growth rates of commercial tree species as well. Very limited local demand for lumber is also a factor.

Establishment of small forest plantations for other uses is feasible. Trees can be grown that are suitable for use as fenceposts and bean poles, for construction of farm and ranch shelters, stockades, and other structures, for furniture and handicraft carving, for firewood, and for charcoal production. Among the trees that are suitable for small forest plantations in the survey area are broad-leaved acacia, kalaskas, and eucalyptus, which are suitable for use as fenceposts; lemmai, ifit, and teak, which are suitable for furniture and handicraft uses; giant tangantangan, which is suitable for firewood or charcoal production or for use as fenceposts; and narra, Honduras mahogany, and binalo, which are suitable for furniture and handicraft uses or for use as fenceposts.

Trees should be planted early in the rainy season for best establishment. Fertilizer should be used during planting. A slow-release fertilizer is suitable. Young trees may need protection from deer on Rota. Weeds should be controlled until the tree crowns join, thus creating shade. Fire protection may be needed if grasslands are nearby. Irrigation during the dry season improves the growth of young trees, particularly on the Banaderu, Chinen, and Luta soils.

There is a severe erosion problem on the Akina soils on Saipan and Rota. The vegetation type on these soils is savannah dominated by swordgrass. Because of the generally steep slopes and poor plant cover, soil slumping occurs. The resulting badland is slow to become revegetated naturally and is subject to intense erosion. Wildfires contribute to the problem by destroying the plant cover, leaving the soils particularly vulnerable to erosion and slumping.

The Commonwealth of the Northern Mariana Islands Department of Natural Resources is working to establish forests on the Akina soils. Once established, these forests are fire resistant and will reduce soil erosion from the sites. This will improve the watershed and provide better wildlife habitat.

Prior to planting an area, prescribed burning is used to remove the existing swordgrass. As the swordgrass resprouts, it is hand cleared or treated with herbicides. Trees are planted by hand on the steep slopes. Slow-release fertilizer should be placed in the planting hole. For 2 years after planting, competing vegetation must be controlled by mowing and ring weeding around the trees. Crown closure will suppress weeds after this. Three years after planting, planted species should exceed 7 meters in height and 15 centimeters in diameter at breast height. Suitable species for planting on Akina soils or other areas where quick forest cover is desired are sickleleaf acacia, broadleaved acacia, da'ok, gagu, *Casuarina cunninghamiana*, and eucalyptus. Of these, the acacias, particularly sickleleaf acacia, are best adapted to the Akina soils. This is the only tree that is suited to Badland areas. Da'ok can be planted on the Akina soils, but it grows more slowly than the other trees do. The casuarina species grow quickly but are flammable and therefore vulnerable to wildfire even when mature. Fruit trees are poorly suited to the Akina soils.

Another forestation program being conducted in the Northern Marianas is the diversification of pure stands of tangantangan. Various species of trees desirable for food, fiber, wood, or for their wildlife habitat value are being planted on a 6-meter spacing. The tangantangan overstory is gradually thinned out as the new trees grow larger and require more sunlight. At some point in the future, perhaps within 10 years, these trees will become dominant.

Woodland Management and Productivity

Table 3 can be used by woodland owners or forest managers in planning the use of soils for wood crops and reforestation. Only those soils suitable for wood crops are listed.

In table 3, *slight, moderate,* and *severe* indicate the degree of the major soil limitations to be considered in management.

Ratings of the *erosion hazard* indicate the risk of loss of soil in well managed woodland. The risk is *slight* if the expected soil loss is small, *moderate* if measures are needed to control erosion during logging and road construction, and *severe* if intensive management or special equipment and methods are needed to prevent excessive loss of soil.

Ratings of *equipment limitation* reflect the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. A rating of *slight* indicates that use of equipment is not limited to a particular kind of equipment or time of year; *moderate* indicates a short seasonal limitation or a need for some modification in management or in equipment; and *severe* indicates a seasonal limitation, a need for special equipment or management, or a hazard in the use of equipment.

Seedling mortality ratings indicate the degree to which the soil affects the mortality of tree seedlings.

Plant competition is not considered in the ratings. The ratings apply to seedlings from good stock that are properly planted during a period of sufficient rainfall. A rating of *slight* indicates that the expected mortality is less than 25 percent; *moderate*, 25 to 50 percent; and *severe*, more than 50 percent.

Ratings of *windthrow hazard* are based on soil characteristics that affect the development of tree roots and the ability of the soil to hold trees firmly. A rating of *slight* indicates that few trees may be blown down by strong winds; *moderate*, that some trees will be blown down during periods of excessive soil wetness and strong winds; and *severe*, that many trees are blown down during periods of excessive soil wetness and moderate or strong winds.

Ratings of *plant competition* indicate the degree to which undesirable plants are expected to invade where there are openings in the tree canopy. The invading plants compete with native plants or planted seedlings. A rating of *slight* indicates little or no competition from other plants; *moderate* indicates that plant competition is expected to hinder the development of a fully stocked stand of desirable trees; *severe* indicates that plant competition is expected to prevent the establishment of a desirable stand unless the site is intensively prepared, weeded, or otherwise managed to control undesirable plants.

Trees to plant are those that are suited to the soils and to rapid forest regeneration under a relatively low level of management.

Windbreaks

Windbreaks can be used very effectively in exposed locations on the islands. Properly designed windbreaks reduce wind damage to young crops and reduce loss of water through evapotranspiration. Such water loss can be particularly significant on the very shallow Luta soils and the shallow Banaderu and Chinen soils.

The dry season trade winds blow primarily from the east and northeast; however, passing tropical storms create crop-damaging winds that can come from any direction. For this reason, windbreaks are needed around the entire perimeter of fields. Windbreaks offer protection over a distance of only about 10 times their height. Wind protection is a factor to be considered when designing field size.

In addition to exposed farm fields, coastal areas with northerly or easterly exposures can also benefit from the use of windbreaks. Plant materials must be able to withstand salt spray.

Unfortunately, windbreaks do not protect crops or property from typhoon-force winds.

Following are plants that are suitable for use as windbreaks and the height some of them can be expected to reach: *Pennisetum purpureum* and *Hibiscus rosa-sinensis*, 2.5 meters; *Cajanus cajun*, 3 meters; *Saccharum spontaneum moentai*, 4.25 meters; *Citrus reticulata*, 5.5 meters; *Leucaena leucocephala*, avocado, and common mango, 7.5 meters; Formosa koa, *Acacia auriculiformis*, and *Acacia mangium*, 9 meters; and horsetail casuarina, *Eucalyptus camaldulensis*, and *Eucalyptus gomphocephala*, 12 meters. Of the above listed plants, *Leucaena leucocephala* and *Eucalyptus gomphocephala* are not suited to the Akina soils.

Assistance in designing windbreaks is available at the local office of the Soil Conservation Service and from extension agents of the Department of Natural Resources, Commonwealth of the Northern Mariana Islands.

Recreation

Recreational use of the soils in the Northern Marianas is increasing rapidly along with the growing tourist industry. There are numerous historical sites that are visited. Picnic and park facilities in coastal areas, particularly on the Shioya soils, receive heavy use. Public and tourist demand will undoubtedly result in further recreational development, both public and private, in coastal areas. Many areas of the broad limestone plateaus are suited to ball field and golf course development. The rugged limestone escarpments and mountains provide breathtaking panoramas and excellent hiking opportunities.

The soils of the survey area are rated in table 4 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 4, the degree of soil limitation is expressed

as slight, moderate, or severe. *Slight* means that soil properties generally are favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 4 can be supplemented by other information in this survey; for example, interpretations for dwellings without basements and for local roads and streets in table 6 and interpretations for septic tank absorption fields in table 7.

Camp areas require site preparation such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils are gently sloping and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking and horseback riding should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

Wildlife Habitat

Wildlife habitat is recognized as an important land use in the Northern Marianas. Within the survey area, the island of Aguijan is a legally designated wildlife habitat reserve. Other islands not included in this survey are also designated as such.

All of the large mammals in the survey area have been introduced onto the islands by man. The binadu (sambar deer), introduced by the Spaniards, is present on Rota and Saipan. Feral goats are hunted on Aguijan. A considerably less desirable introduced mammal, the cha'ka (roof rat), is now abundant on all the islands.

Two species of bat are the only native mammals in the Northern Marianas. The fanihi (Marianas fruit bat) was once abundant in the forests of the Northern Marianas, but it has been hunted extensively for food. The fanihi is now being considered for endangered species status, and hunting is prohibited on the islands in the survey area.

Another native species that is used for food is the ayuyu, or coconut crab. Ayuyu are found in forests throughout the islands.

The hilitai, or monitor lizard, is an introduced species. The largest reptile on the islands, hilitai commonly are about a meter long. Other reptiles and amphibians include numerous skinks and geckos, the kairo' (marine toad), and the blind snake.

The most abundant and diverse wildlife group is birds. Such species as Chichirika (Rufous fantail), Totot (Marianas fruit dove), and Nosa' (bridled white-eye) are abundant in the forests. Fahang (noddy terns) are common along coastal cliffs and offshore islets. Yayaguak (Vanikoro swiftlets), Chunge' (white terns), and Fakpe (white-tailed tropicbirds) are a familiar sight near limestone cliffiines.

Several rare and endangered species of bird live in the Northern Marianas, including the Sasngat (Micronesian megapode), Nganga' (Marianas mallard), Ga'karisu (nightingale reed-warbler), Chuchurican Chokulati (Tinian monarch), Aga (Marianas crow), and Yayaguak.

Savannah fires affect different wildlife species in different ways. Fires may destroy active nests of savannah birds such as the black frankolin, blue-breasted quail, and yellow bittern. Fire also restricts distribution of forests, which provide cover for mammals and habitat for many birds. On the other hand, fire consumes dry, low-quality forage and results in lush

new growth that is highly palatable to mammals.

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 5, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

The elements of wildlife habitat are described in the following paragraphs.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and hazard of flooding. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are foxtail, guineagrass, napiergrass, bittermelon, and beggartick.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and other foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are kafo', ladda, lemmai, laguanaha, and papaya. Examples of fruit-producing shrubs that are suitable for planting on soils rated good are pi'ot, pitanga, and ibba'.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, and foliage. Soil properties and features that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and soil moisture. Examples of shrubs are abas, tintanchina, lemonchina, and chosgo.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are karisu, paragrass, taro, sedges, and reeds.

Shallow water areas have an average depth of less than 150 centimeters. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfoul feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of cropland, pasture, rangeland, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grasses and wild herbaceous plants. The wildlife attracted to these areas include the hilitai, cha'ka, Nosa', Sihek (collared kingfisher), Dulili (lesser golden plover), and the Paluman Sinisa (Philippine turtle dove).

Habitat for woodland wildlife consists of areas of forest trees and shrubs and associated grasses and wild herbaceous plants. Wildlife attracted to these areas include the binadu, fanihi, ayuyu, and hilitai and birds such as the Totot, Sihek, Aga, Chichirika, Sali (Micronesian starling), Nosa', and Chuchurican Chokulati.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to these areas are the Pulattat (Marianas gallinule), kakkak (yellow bittern), Ga'karisu, and various species of migratory waterfowl.

Engineering

This section provides information for planning land uses related to urban development and to water

management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building Site Development, Sanitary Facilities, Construction Materials, and Water Management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 150 centimeters. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations need to be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 150 centimeters of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of construction conditions; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps and soil descriptions, and other data provided in this survey can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Building Site Development

Table 6 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features generally are favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of about 150 centimeters to 180 centimeters for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and small commercial buildings are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to

bedrock or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 150 centimeters are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills generally are limited to less than 180 centimeters. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 100 centimeters, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Sanitary Facilities

Table 7 shows the degree and the kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features generally are favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 7 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 60 and 180 centimeters is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 120 centimeters below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 60 to 150 centimeters. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 7 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 30 to 60 centimeters of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage because of rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause

construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 7 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 180 centimeters. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to wind erosion.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

Table 8 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a probable or improbable source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 150 centimeters.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 180 centimeters high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 150 centimeters. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel, or both. They have at least 150 centimeters of suitable material, low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 90 centimeters. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 30 to 90 centimeters. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 30 centimeters. They may have layers of suitable material, but the material is less than 90 centimeters thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 8, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific

purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the taxonomic unit descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a *probable* source has a layer of clean sand or gravel or a layer of sand or gravel that is as much as 12 percent silty fines. This material must be at least 90 centimeters thick and less than 50 percent, by weight, large stones. All other soils are rated as an *improbable* source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 100 centimeters of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable loamy material to a depth of at least 40 centimeters. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 50 to 100 centimeters of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 50 centimeters of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils generally is preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Water Management

Table 9 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and for embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features generally are favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage, irrigation, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 150 centimeters. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 6 meters high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 150 centimeters. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even more than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 150 centimeters of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and

effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, or sulfur. Availability of drainage outlets is not considered in the ratings.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock or to a cemented pan. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features listed in tables are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help to characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classifications, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

Engineering Index Properties

Table 10 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 150 to 180 centimeters.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each taxonomic unit under "Soil Series and Their Morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as 15 percent, an appropriate modifier is added; for example, "gravelly." Textural terms are defined in the Glossary.

Classification of the soils is determined according to the system adopted by the American Association of State Highway and Transportation Officials *(1)* and the Unified soil classification system *(2)*.

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 8 centimeters in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification; for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 8 centimeters in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6.

Rock fragments larger than 8 centimeters in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates

determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than about 7.5 centimeters in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series),have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

The estimates of grain-size distribution, liquid limit, and plasticity index are rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is omitted in the table.

Physical and Chemical Properties

Table 11 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each taxonomic unit under "Soil Series and Their Morphology."

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at ⅓ bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in centimeters of water per centimeter of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil

for crop production, the stability of the soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, more than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, very fine sand, sand, and organic matter (as much as 4 percent) and on soil structure and permeability. The estimates are modified by the presence of rock fragments. Values of K range from 0.02 to 0.69. The higher the value the more susceptible the soil is to sheet and rill erosion.

Erosion factor T is an estimate of the maximum average rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Organic matter is the plant and animal residue in the soil at various stages of decomposition.

In table 11, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter of a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

Soil and Water Features

Table 12 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sand or gravelly sand. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potenital) when thoroughly wet. These consist chiefly of clay that has high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding, the temporary covering of the soil surface by flowing water, is caused by overflow from streams, by runoff from adjacent slopes, or by inflow from high tides. Shallow water standing or flowing for short periods after rainfall or snowmelt is not considered to be flooding. Standing water in swamps and marshes or in closed depressional areas is considered to be ponding.

Table 12 gives the frequency and duration of flooding and the time of year when flooding is most likely to occur.

Frequency, duration, and probable period of flooding are estimated. Frequency is expressed as *none, rare, occasional,* and *frequent*. *None* means that flooding is not probable, *rare* that it is unlikely but is possible under unusual weather conditions (chance of flooding in any

year is 0 to 5 percent), *occasional* that it occurs infrequently under normal weather conditions (chance of flooding in any year is 5 to 50 percent), and *frequent* that it occurs often under normal weather conditions (chance of flooding in any year is more than 50 percent).

Duration is expressed as *very brief* (less than 2 days), *brief* (2 to 7 days), *long* (7 days to 1 month), and *very long* (more than 1 month). The time of year that flooding is most likely to occur is expressed in months. November-May, for example, means that flooding can occur during the period November through May. About two-thirds to three-fourths of all flooding occurs during the stated period.

The information on flooding is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons, which are characteristic of soils that are not subject to flooding.

Also considered are local information about the extent and level of flooding and the relation of each soil on the landscape to historic flood. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 12 are the depth to the seasonal high water table; the kind of water table—that is, *perched*, *artesian*, or *apparent*; and the months of the year that the water table usually is highest. A water table that is seasonally high for less than 1 month is not indicated in the table.

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. An *artesian* water table is under hydrostatic head, generally below an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole. A *perched* water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower water table by a dry zone.

The two numbers in the column "High water table" indicate the normal range in depth to a saturated zone. Depth is given to the nearest half foot. The first numeral in the range indicates the highest water level. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. "More than 1.8" indicates that the water table is below a depth of 1.8 meters or that the water table exists for less than a month.

Depth to bedrock is given if bedrock is within a depth of 150 centimeters. The depth is based on many soil borings and on observations during soil mapping. The rock is specified as either soft or hard. If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

Subsidence is the settlement of organic soils or of saturated mineral soils of very low density. Subsidence results from either desiccation and shrinkage or oxidation of organic material, or both, following drainage. Subsidence takes place gradually, usually over a period of several years. Table 12 shows the expected initial subsidence, which usually is a result of drainage, and annual subsidence, which usually is a result of oxidation.

Not shown in the table is subsidence caused by an imposed surface load or by the withdrawal of ground water throughout an extensive area as a result of lowering the water table.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories *(16)*. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 13 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Ultisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Ustults (*Ust*, meaning burnt, plus *ult*, from Ultisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Haplustults (*Hapl*, meaning simple, plus *ustult*, the suborder of the Ultisols that occurs where there is a pronounced dry season).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Haplustults (not in this survey area). Oxic Haplustults is an example of an intergrade.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, thickness of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is clayey, kaolinitic, isohyperthermic Oxic Haplustults.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soil and the material in which it formed are identified for each series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the *Soil Survey Manual (15)*. Many of the technical terms used in the descriptions are defined in *Soil Taxonomy (16)*. Unless otherwise stated, colors in the descriptions are for moist soil and textures are apparent field textures. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed Soil Map Units."

Agfayan Variant

The Agfayan Variant consists of shallow, well drained soils on volcanic uplands. These soils formed in residuum and colluvium derived from dacite. Slope is 15 to 60 percent. The mean annual precipitation is about 210 centimeters, and the mean annual temperature is about 25 degrees C.

Taxonomic Class

Loamy, mixed, isohyperthermic, shallow Udorthentic Haplustolls

Typical Pedon

Agfayan Variant very cobbly clay; in an area of Agfayan Variant-Rock outcrop complex, 30 to 60 percent slopes; under mixed native forest.

A—0 to 16 centimeters; very dark gray (10YR 3/1) very cobbly clay with patches of dark gray (10YR 4/1); moderate fine subangular blocky structure; friable, sticky and plastic; many very fine and common fine roots; 50 percent of surface is covered with pebbles, cobbles, and stones; sand fraction is dominantly angular quartz grains; medium acid (pH 5.8); clear smooth boundary.

C—16 to 35 centimeters; dark grayish brown (10YR 4/2) cobbly clay loam; moderate fine subangular blocky structure; friable, slightly sticky and slightly plastic; many very fine and common fine roots; common very fine and fine tubular pores; sand fraction is dominantly angular quartz grains; slightly acid (pH 6.3); gradual wavy boundary.

Cr—35 centimeters; light brownish gray (10YR 6/2) and white (10YR 8/2) saprolitic dacite with reddish yellow (7.5YR 6/8) flecks; rubs to sandy loam; few roots extend along fracture planes.

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; on the southern slope of Osko Achugao, about 1 kilometer south of San Roque Village; lat. 15°14′15″ N. and long. 145°46′15″ E.

Range in Characteristics

Profile: soil moisture—usually dry for 90 to 120 cumulative days, usually moist from July through December; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; mollic epipedon thickness—10 to 22 centimeters (shallower epipedons rest directly on bedrock); depth to dacite—25 to 50 centimeters; clay content—20 to 35 percent.

A horizon: color—N 2/0, 7.5YR 3/2, or 10YR 3/1 or 3/2; texture—sandy loam, loam, clay loam, or clay; rock fragment content—35 to 60 percent (about 50 percent is pebbles and 50 percent is stones and cobbles, mostly on surface); reaction—medium acid to neutral.

C horizon: color—10YR 4/1, 4/2, or 3/4 or 5YR 3/4 or 4/4; texture—loam or clay loam; rock fragment content—10 to 30 percent pebbles and cobbles; reaction—slightly acid to neutral; other features—C horizon is not present in all pedons.

Cr horizon: color—10YR 6/2 or 8/2 or 5Y 6/1.

Akina Series

The Akina series consists of moderately deep, well drained soils on volcanic uplands. These soils formed in residuum derived from tuff or tuff breccia. Slope is 5 to 60 percent. The mean annual precipitation is about 230 centimeters, and the mean annual temperature is about 25 degrees C.

Taxonomic Class

Clayey, kaolinitic, isohyperthermic Oxic Haplustults

Typical Pedon

Akina silty clay; in an area of Akina-Badland complex, 15 to 30 percent slopes; under savannah.

A1—0 to 4 centimeters; dark brown (7.5YR 3/2) silty clay, dark brown (7.5YR 3/3) dry; moderate very fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine and few fine roots; many very fine interstitial pores; sand fraction is dominantly angular quartz grains; medium acid (pH 5.6); abrupt smooth boundary.

A2—4 to 15 centimeters; mixed dark reddish brown (5YR 3/3 and 3/4) clay, dark reddish brown (5YR 3/2) dry; strong very fine subangular blocky structure; slightly hard, very friable, sticky and plastic; many very fine and few fine roots; many very fine and few fine and medium tubular pores and many very fine interstitial pores; sand fraction is dominantly angular quartz grains; few pebbles; strongly acid (pH 5.3); clear wavy boundary.

Bt1—15 to 55 centimeters; dark red (2.5YR 3/6) clay, red (2.5YR 4/6) dry; yellowish red (5YR 4/6) faces of peds; moderate medium prismatic structure parting to strong coarse angular blocky; hard, firm, very sticky and very plastic; common very fine and few fine roots; common very fine, fine, and

medium tubular pores; continuous thin clay films on faces of peds and continuous moderately thick clay films lining pores; few dark brown (7.5YR 3/2) worm casts; many fine sand-sized black manganese concretions; few angular quartz sand grains; few pebbles; strongly acid (pH 5.3); diffuse smooth boundary.

Bt2—55 to 70 centimeters; dark red (2.5YR 3/6) clay, red (2.5YR 4/6) dry; yellowish red (5YR 4/6) ped faces; common reddish yellow (7.5YR 6/6) and yellow (10YR 7/6) sand-sized saprolitic flecks in peds; weak medium prismatic structure parting to strong fine and medium angular blocky; very hard, firm, very sticky and very plastic; common very fine and few fine roots; common very fine and fine tubular pores and few medium tubular pores; few thin clay films on ped faces and continuous thin and moderately thick clay films lining pores; many fine sand-sized black manganese concretions; few angular quartz sand grains; few pebbles; strongly acid (pH 5.3); gradual wavy boundary.

C—70 to 84 centimeters; variegated dark red (2.5YR 3/6) and red (2.5YR 4/8 and 5/8) clay with many medium and coarse patches of light brown and pinkish white (7.5YR 6/4 and 8/2) weathering mineral grains; crushed color is red (2.5YR 4/6); massive; hard, friable, sticky and plastic; few very fine roots; common very fine and fine tubular pores and few medium tubular pores; continuous moderately thick and thick clay films lining pores; few pebbles; strongly acid (pH 5.3); diffuse smooth boundary.

Cr—84 centimeters; saprolitic tuff that crushes to loam; 50 percent is white (10YR 8/2) sand-sized saprolitic flecks with reddish yellow (5YR 6/8) stains on faces and 50 percent is dark red (2.5YR 3/6) matrix; yellowish red (5YR 4/6) on fracture planes and in pores; massive; hard, friable, sticky and plastic; few very fine roots, mainly along fracture planes; few very fine, fine, and medium tubular pores; continuous thin clay films lining pores; few pebbles; strongly acid (pH 5.3).

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; about 2.5 kilometers northeast of the Trust Territory capitol building along Ridge Road, about 50 meters northeast of the forest and savannah boundary; lat. 15°13′50″ N. and long. 145°46′5″ E.

Range in Characteristics

Profile: soil moisture—usually dry in the moisture control section for 90 to 120 cumulative days, usually moist from July through December; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; depth to paralithic contact—50 to 100 centimeters; clay content of argillic horizon—60 to 80 percent.

A horizon: color—2.5YR 2.5/2 or 3/4, 5YR 2.5/2, 3/2, 3/3, or 3/4, 7.5YR 3/1 or 3/2, or 10YR 3/3; texture—silty clay, clay, or clay loam; reaction—strongly acid to medium acid; gravel on surface—0 to 10 percent.

B horizon: color—10R 3/4 or 3/6, 2.5YR 3/4, 3/6, or 4/6, or 5YR 4/6; reaction—very strongly acid to medium acid; other features—common sand- and gravel-sized saprolitic flecks in the lower part of the B horizon (flecks commonly have color value and chroma of more than 3 and as much as 8), in some pedons the B horizon is not subdivided.

C horizon: present in some pedons.

Cr horizon: color—mixed, with dominant matrix color of 2.5YR 3/6, 4/6, or 4/8 (other colors include hue of 5YR, 7.5YR, or 10YR in value of more than 3 and variable chroma; these subordinate colors commonly are present as discrete sand- and gravel-sized saprolitic flecks and bands); structure—massive; consistence when moist—friable to very firm.

Banaderu Series

The Banaderu series consists of shallow, well drained soils on uplifted limestone plateaus. These soils formed in sediment overlying coralline limestone. Slope is 3 to 30 percent. The mean annual precipitation is about 220 centimeters, and the mean annual temperature is about 25 degrees C.

Taxonomic Class

Clayey, gibbsitic, isohyperthermic Lithic Argiustolls

Typical Pedon

Banaderu clay loam, 5 to 15 percent slopes; under secondary forest on a 10 percent southeasterly slope.

Oi—2 centimeters to 0; undecomposed leaf litter.

A1—0 to 2 centimeters; black (N 2/0) clay loam, dark reddish brown (5YR 2.5/2) dry; strong very fine granular structure; slightly hard, friable, nonsticky and slightly plastic; many very fine and fine roots and few medium roots; many very fine interstitial pores; about 10 to 20 percent sand-sized nodules that can be crushed; occasional cobbles; neutral

(pH 7.0); clear smooth boundary.

A2—2 to 18 centimeters; black (5YR 2.5/1) clay loam, dark reddish brown (5YR 3/2) dry; strong fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine and fine roots and few medium roots; many very fine interstitial pores; about 10 to 20 percent sand-sized nodules that can be crushed; occasional cobbles; mildly alkaline (pH 7.4); clear wavy boundary.

Bt1—18 to 40 centimeters; dusky red (10R 3/4) clay, weak red (10R 4/4) dry; moderate very fine and fine subangular blocky structure parting to strong fine granular; hard, friable, sticky and plastic; common very fine roots and few fine and medium roots; common very fine and fine and few medium tubular pores; few moderately thick clay films lining pores and common thin clay films on ped faces; few very fine manganese concretions; mildly alkaline (pH 7.4); gradual wavy boundary.

Bt2—40 to 48 centimeters; dark red (10R 3/6) clay; weak fine subangular blocky structure; hard, friable, very sticky and plastic; common very fine and few fine roots; common very fine and fine and few medium tubular pores; many thin, common moderately thick, and few thick pressure faces; very few intermittent areas with common thin dark grayish brown (10YR 4/2) clay films on ped faces and many thin, sugary, reddish yellow (7.5YR 6/8) coatings lining pores; few very fine manganese concretions; mildly alkaline (pH 7.6); abrupt broken boundary.

2R—48 centimeters; pinnacles of jagged, irregular, white unweathered limestone; many holes and fissures.

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; west of the summit of Suicide Cliff, about 330 meters west on the Banaderu Trail, about 9 meters south of trail; lat. 15°16'40" N. and long. 145°48'25' E.

Range in Characteristics

Profile: soil moisture—usually dry for 90 to 120 cumulative days, primarily between February and May, and usually moist from July through December; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; mollic epipedon thickness—18 to 22 centimeter (some pedons have an A horizon as shallow as 15 centimeters, but mixing the upper 18 centimeters meets the requirements of a mollic epipedon); depth to bedrock—25 to 50 centimeters; clay content of argillic horizon—40 to 60 percent.

A horizon: color—N 2/0, 5YR 2.5/1, 3/2, or 3/3, 2.5YR 3/2, or 10YR 3/2; texture—clay loam or clay; structure—granular or subangular blocky; rock fragment content—5 to 20 percent (about 50 percent is cobbles and less than 5 percent is stones).

B horizon: color—dominantly 10R 3/4 or 3/6 but ranges to 2.5YR 3/4 or 3/6; structure—prismatic or subangular blocky; rock fragment content—0 to 10 percent (mostly angular cobbles); other features—coatings on ped faces and pores that have colors different from those in the matrix are not present in all pedons (colors of coatings include matrix colors, as well as 10YR 4/2, 5YR 4/6, or 7.5YR 6/8).

Chacha Series

The Chacha series consists of deep, somewhat poorly drained soils in level and depressional areas on limestone plateaus. These soils formed in sediment overlying coralline limestone. Slope is 0 to 5 percent. The mean annual precipitation is about 220 centimeters, and the mean annual temperature is about 27 degrees C.

Taxonomic Class

Very fine, kaolinitic, isohyperthermic Oxic Haplustalfs

Typical Pedon

Chacha clay, drained, 0 to 5 percent slopes; under grasses and forbs in a level area.

Ap—0 to 17 centimeters; dark yellowish brown (10YR 3/4) clay, dark yellowish brown (10YR 4/4) dry; moderate medium and coarse subangular blocky structure; very hard, very firm, very sticky and very plastic; many very fine and few fine roots; few very fine tubular pores and few very fine and fine interstitial pores; about 3 percent fine angular limestone pebbles; about 15 percent black round manganese concretions 2 to 5 millimeters in diameter; few fine pieces of Bt1 horizon; horizon compacted by surface traffic; mildly alkaline (pH 7.6); abrupt smooth boundary.

Bt1—17 to 42 centimeters; strong brown (7.5YR 5/6) clay with few medium faint patches of reddish brown (5YR 4/4); moderate medium prismatic structure parting to moderate medium and coarse angular blocky; very hard, firm, very sticky and very plastic; many very fine roots; common very fine and few fine tubular pores and few very fine and fine

interstitial pores; continuous thick dark brown (7.5YR 4/4) clay films on faces of peds and in pores; about 50 percent of horizon has pockets of rounded black manganese concretions and nodules 2 to 5 millimeters in diameter; matrix is stained dark brown (7.5YR 4/4) in vicinity of concretions; mildly alkaline (pH 7.4); gradual wavy boundary.

Bt2—42 to 66 centimeters; strong brown (7.5YR 5/6) clay with few medium faint patches of reddish brown (5YR 4/4); moderate medium prismatic structure parting to moderate medium and coarse angular blocky; firm, very sticky and very plastic; few very fine roots; few very fine and fine tubular pores; continuous thick dark brown (7.5YR 4/4) clay films on faces of peds and in interstitial pores; continuous black manganese and organic stains along most pores; about 2 percent black rounded manganese concretions 1 to 5 millimeters in diameter; slightly acid (pH 6.4); gradual wavy boundary.

Bt3—66 to 100 centimeters; strong brown (7.5YR 5/6) clay with many medium distinct patches of dark red (2.5YR 3/6); weak medium prismatic structure parting to strong medium angular blocky; firm, very sticky and very plastic; few very fine roots; few very fine and fine tubular pores; continuous moderately thick dark yellowish brown (10YR 4/4) clay films on ped faces and in pores and dark grayish brown (10YR 4/2) films lining pores; pressure faces on vertical ped faces; strongly acid (pH 5.2); gradual wavy boundary.

Cg—100 to 150 centimeters; variegated with 45 percent strong brown (7.5YR 5/6), 45 percent dark red (2.5YR 3/6), and 10 percent light gray (10YR 7/2) clay; the dark red material is in medium and coarse textured patches and the light gray material is in 2- to 5-millimeter thick layers in cleavage planes; strong medium angular blocky structure; firm, sticky and plastic, but light gray material is very sticky; few very fine roots; few very fine tubular pores; continuous thick dark brown (10YR 4/3) clay films on vertical cleavage planes that are 5 to 10 centimeters apart; dark gray (10YR 4/1) stains along pores; strong undulating pressure faces on all light gray (10YR 7/2) cleavage planes; pressure faces on all peds; very strongly acid (pH 5.0).

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; Kagman Experiment Station, about 30 meters east of the station entrance; lat. 15°10'25" N. and long. 135°46'5" E.

Range in Characteristics

Profile: soil moisture—usually dry for 90 to 120 consecutive days, mainly between February and May, and usually moist from July through December; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; clay content—60 to 80 percent; reticulate mottling—present in all pedons below a depth of 100 centimeters (consists of matrix colors of 7.5YR 5/6 or 5/8 or 2.5YR 3/6 or 4/6 and intersecting bands of 10YR 7/2, 7/4, or 7/6, with stains of 10YR 4/1 or 4/3).

A horizon: color—10YR 3/2, 3/3, or 3/4 or 7.5YR 3/2; texture—clay loam, silty clay, or clay; pebble content—0 to 5 percent.

B horizon: dominantly 7.5YR 4/4, 4/6, 5/6, or 5/8 and commonly has mixed colors of 2.5YR 3/6, 4/3, 4/6, 5/6, or 5/8 or 5YR 4/4 in the lower part; texture—clay or silty clay.

Chinen Series

The Chinen series consists of shallow, well drained soils on uplifted plateaus. These soils formed in sediment overlying porous limestone. Slope is 3 to 30 percent. The mean annual precipitation is about 220 centimeters, and the mean annual temperature is about 25 degrees C.

Taxonomic Class

Clayey, oxidic, isohyperthermic Lithic Argiustolls

Typical Pedon

Chinen clay loam, 0 to 5 percent slopes; under secondary forest on a 3 percent, east-facing slope.

Oi—1 centimeter to 0; undecomposed leaf litter.

A1—0 to 6 centimeters; very dark grayish brown (10YR 3/2) clay loam, very dark grayish brown (10YR 3/2) dry; strong very fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots and few medium and coarse roots; many very fine interstitial pores; common worm casts; about 10 percent pebbles and cobbles; mildly alkaline (pH 7.6); abrupt smooth boundary.

Bt1—6 to 18 centimeters; dark brown (7.5YR 3/2) clay, dark brown (10YR 3/3) dry; moderate very fine subangular blocky structure; hard, friable, sticky and slightly plastic; few very fine and medium roots and common fine roots; many very fine interstitial pores and few very fine tubular pores; many sand-sized

nodules that crush to clay; about 10 percent pebbles and cobbles; mildly alkaline (pH 7.6); gradual wavy boundary.

Bt2—18 to 35 centimeters; yellowish red (5YR 4/6) clay loam; weak fine subangular blocky structure; very friable, slightly sticky and slightly plastic; few very fine and fine roots; many very fine, common fine, and few medium tubular pores; common thin clay films on faces of peds and continuous thin clay films lining pores; mildly alkaline (pH 7.6); abrupt irregular boundary.

2R—35 centimeters; pinnacles of unweathered white limestone; many holes and fissures.

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; at the east end of Kagman airstrip (abandoned), about 50 meters southeast of the road head to Marine Beach (Unai Laolao Kattan); lat. 15°9'55" N. and long. 145°46'40" E.

Range in Characteristics

Profile: soil moisture—usually dry for 90 to 120 cumulative days and usually moist from July through December; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; mollic epipedon thickness—18 to 22 centimeters, but as little as 14 centimeters in some pedons; other features—upper part of Bt horizon meets requirements of mollic epipedon; depth to bedrock—25 to 50 centimeters; clay content of argillic horizon—50 to 80 percent

A horizon: color—N 2/0, 10YR 2/1, 3/1, or 3/2, or 7.5YR 3/2; texture—clay loam or clay; rock fragment content—2 to 15 percent (about 50 percent is pebbles, and 50 percent is cobbles).

B horizon: color—dominantly 5YR 4/4 or 4/6 and 7.5YR 3/2, 4/4, or 4/6 but ranges to 5YR 3/3, 3/4, 5/6, or 5/8, 7.5YR 3/4, 5/6, or 5/8, or 10YR 3/1, 3/2, 3/3, 4/3, 4/4, or 5/4; texture—clay or silty clay; consistence—slightly sticky and sticky; rock fragment content—0 to 15 percent (about 50 percent is pebbles, and 50 percent is cobbles).

Dandan Series

The Dandan series consists of moderately deep, well drained soils on uplifted limestone plateaus. These soils formed in sediment overlying porous coralline limestone. Slope is 0 to 15 percent. The mean annual precipitation is about 200 centimeters, and the mean annual temperature is about 25 degrees C.

Taxonomic Class

Fine, oxidic, isohyperthermic Oxic Haplustalfs

Typical Pedon

Dandan clay in an area of Dandan-Chinen complex, 0 to 5 percent slopes; under secondary forest on a 2 percent slope.

A1—0 to 2 centimeters; very dark brown (10YR 2/2) clay loam, dark brown (7.5YR 3/2) dry; strong very fine and fine granular structure; slightly hard, firm, slightly sticky and plastic; common very fine roots; many very fine and common fine interstitial pores; material is dominantly worm casts; medium acid (pH 5.6); abrupt smooth boundary.

A2—2 to 12 centimeters; dark brown (7.5YR 3/2) clay, dark brown (7.5YR 3/2) dry; moderate fine and very fine subangular blocky structure; slightly hard, firm, sticky and plastic; few very fine roots and common fine roots; common very fine interstitial pores and few fine tubular pores; slightly acid (pH 6.4); clear wavy boundary.

Bt1—12 to 30 centimeters; dark reddish brown (5YR 3/4) clay that is dark reddish brown (5YR 3/3) on ped faces, reddish brown (5YR 4/4) dry; weak medium prismatic structure parting to moderate fine subangular blocky; hard, friable, sticky and plastic; few very fine roots and common fine roots; common fine tubular pores; many thin and few moderately thick clay films on ped faces and many thin clay films in pores; neutral (pH 6.6); clear wavy boundary.

Bt2—30 to 66 centimeters; reddish brown (5YR 4/4) clay that is dark reddish brown (5YR 3/4) on ped faces; weak medium prismatic structure parting to moderate medium subangular blocky; hard, firm, sticky and plastic; few very fine, common fine, and few medium roots; common very fine and fine tubular pores; about 5 percent very fine manganese concretions; many thin and few moderately thick clay films on ped faces and many thin clay films in pores; neutral (pH 6.6); abrupt irregular boundary.

2R—66 centimeters; unweathered white limestone; occasional large holes and fissures.

Type Location

Tinian, Commonwealth of the Northern Mariana Islands; about 1.3 kilometers southeast of Puntan Lamanibot Sanhilo, on the western coast; 900 meters west from the T intersection of an unnamed paved road and 8th Avenue, 2.5 kilometers south of the traffic circle; 120

meters north into the forest; lat. 15°2'45" N. and long. 145°36'5" E.

Range in Characteristics

Profile: soil moisture—usually dry in the moisture control section for 90 to 120 cumulative days, usually moist from July through December; soil temperature—24 degrees C to 26 degrees with less than 2 degrees variation between summer and winter; depth to bedrock—50 to 100 centimeters deep over limestone; clay content of argillic horizon—40 to 60 percent.

A horizon: total thickness—7 to 18 centimeters; color—10YR 2/2, 3/1, 3/2, or 3/3, 7.5YR 2/2 or 3/2, or 5YR 2.5/2 or 3/2; texture—clay loam or clay; structure—granular or subangular blocky; reaction—medium acid to neutral; rock fragment content—0 to 10 percent (mostly pebbles).

B horizon: color—5YR or 7.5YR 3/3, 3/4, 4/4, or 4/6; reaction—slightly acid to mildly alkaline.

Inarajan Series

The Inarajan series consists of very deep, somewhat poorly drained soils on valley bottoms and coastal plains. These soils formed in alluvium. Slope is 0 to 5 percent. The mean annual precipitation is about 230 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic Class

Very fine, mixed, nonacid, isohyperthermic Aeric Tropic Fluvaquents

Typical Pedon

Inarajan clay, 0 to 5 percent slopes; under grasses and forbs.

A1—0 to 18 centimeters; black (5Y 2.5/1) clay; weak medium subangular blocky structure; friable, very sticky and very plastic; few fine and very fine roots; few very fine and common fine and medium tubular pores and few very fine interstitial pores; about 5 percent uncoated quartz sand grains; neutral (pH 7.2); gradual wavy boundary.

A2—18 to 40 centimeters; mixed very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) clay; many fine and medium distinct mottles of dark grayish brown (2.5Y 4/2) and reddish brown (5YR 4/4); moderate fine subangular blocky structure; friable, very sticky and very plastic; few very fine roots; few very fine, fine, and medium tubular pores; about 5 percent uncoated quartz sand grains; neutral (pH 7.2); gradual wavy boundary.

C1—40 to 70 centimeters; dark yellowish brown (10YR 4/4) clay; many medium and large prominent mottles of dark gray (5Y 4/1); massive; very friable, very sticky and very plastic; few very fine roots; common very fine tubular pores; many saprolitic sand-sized grains of variable color; neutral (pH 7.2); gradual smooth boundary.

C2—70 to 90 centimeters; mixed dark yellowish brown (10YR 4/6) and yellowish brown (10YR 5/6) clay; many fine and medium prominent gray (5Y 5/1) mottles; massive; very friable, very sticky and very plastic; few very fine roots; common very fine tubular pores; many saprolitic sand-sized grains of variable color; neutral (pH 7.2); clear smooth boundary.

C3—90 to 120 centimeters; mixed dark yellowish brown (10YR 4/6) and yellowish brown (10YR 5/6) clay; many fine and medium prominent gray (5Y 5/1) mottles; massive; very friable, very sticky and very plastic; few very fine roots; common very fine tubular pores; about 20 percent quartz sand and 5 percent volcanic pebbles; neutral (pH 7.2); gradual smooth boundary.

C4—120 to 150 centimeters; brown (7.5YR 4/4) clay; many fine and medium prominent mottles of gray (5Y 5/1); massive; very friable, very sticky and very plastic; few very fine roots; common very fine tubular pores; about 20 percent quartz sand and 5 percent volcanic pebbles; about 15 percent manganese nodules, concretions, and stains; neutral (pH 7.2).

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; about 0.5 kilometer southwest of San Roque Village, 50 meters southeast of the west coast highway; lat. 15°14'40" N. and long. 145°46'0" E.

Range in Characteristics

Profile: soil moisture—usually dry in the upper part for 60 to 90 cumulative days, usually moist or wet between June and January and saturated to the surface for significant periods of time; depth to water table—30 to 100 centimeters during most of the rainy season, receding during the dry season; soil temperature—25 to 29 degrees C, with less than 2 degrees difference between summer and winter; clay content—60 to 90 percent, but in some pedons individual strata are less than 60 percent clay.

A horizon: thickness—25 to 50 centimeters; color—10YR 2.5/1, 3/1, or 3/2, 2/5Y 3/1 or 3/2, 5Y 2.5/1, or N 2/0; other features—buried A horizon is present in some pedons.

C horizon: matrix color—hue of 5YR, 7.5YR, or 10YR, value of 3, 4, or 5, chroma of 4 or 6; color of mottles—hue of 2.5Y or 5Y, value of 4 or 5, chroma of 1 or 2 (oxidation mottles are also present in some horizons of many pedons); reaction—slightly acid or neutral.

Kagman Series

The Kagman series consists of very deep, well drained soils on uplifted plateaus. These soils formed in sediment overlying coralline limestone. Slope is 0 to 15 percent. The mean annual precipitation is 230 centimeters, and the mean annual temperature is 25 degrees C.

Taxonomic Class

Very fine, kaolinitic, isohyperthermic Oxic Paleustalfs

Typical Pedon

Kagman clay, 0 to 5 percent slopes; under a forest of *Leucaena leucocephala* and *Albizia lebbeck* on a 2 percent slope.

A1—0 to 2 centimeters; very dark grayish brown (10YR 3/2) clay, very dark grayish brown (10YR 3/2) dry; strong fine granular structure; friable, sticky and plastic; common very fine roots and few fine roots; many very fine and common fine interstitial pores; material is dominantly worm casts; mildly alkaline (pH 7.4); abrupt smooth boundary.

A2—2 to 15 centimeters; dark brown (10YR 3/3) clay, dark brown (10YR 3/3) dry; moderate very fine and fine subangular blocky structure; friable, very sticky and very plastic; common very fine roots and few fine roots; common very fine and fine interstitial pores and common very fine tubular pores; few thin clay films on faces of peds; about 5 percent manganese concretions 1 to 2 millimeters in diameter; mildly alkaline (pH 7.4); abrupt smooth boundary.

Bt1—15 to 42 centimeters; strong brown (7.5YR 5/6) clay that is dark brown (10YR 3/3) on vertical ped faces; moderate medium prismatic structure parting to moderate fine subangular blocky; friable, very sticky and very plastic; common very fine roots and few fine roots; common very fine and fine tubular pores; continuous moderately thick clay films on faces of peds and lining pores; about 5 percent manganese concretions 1 to 2 millimeters in diameter; mildly alkaline (pH 7.4); gradual wavy boundary.

Bt2—42 to 70 centimeters; strong brown (7.5YR 5/6) clay; moderate medium prismatic structure parting to moderate medium subangular blocky; friable, very sticky and very plastic; few very fine and medium roots; common very fine and fine tubular pores and common very fine interstitial pores; continuous moderately thick clay films on faces of peds and lining pores; about 5 percent manganese concretions 1 to 2 millimeters in diameter; mildly alkaline (pH 7.4); gradual wavy boundary.

Bt3—70 to 95 centimeters; strong brown (7.5YR 5/6) clay; few medium distinct red (2.5YR 4/8) patches; moderate medium prismatic structure parting to moderate medium subangular blocky; friable, very sticky and very plastic; few very fine and fine flattened roots; common very fine and fine tubular pores; continuous moderately thick clay films on faces of peds and lining pores; about 5 to 10 percent very fine patches of manganese stains on faces of peds and along pores; mildly alkaline (pH 7.4); diffuse wavy boundary.

Bt4—95 to 150 centimeters; strong brown (7.5YR 5/6) clay; few medium distinct red (2.5YR 4/8) patches; moderate medium prismatic structure parting to moderate medium subangular blocky; friable, very sticky and very plastic; few very fine roots; common very fine and fine tubular pores; continuous moderately thick clay films on faces of peds and lining pores; very fine patches of manganese stains on faces of peds and along pores; mildly alkaline (pH 7.4).

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; along road south of Susupe Golf Course, south (right) fork about 640 meters from highway intersection, 200 meters further to next fork, then 14 meters west of road; lat. 15°9′35″ N. and long. 145°43′0″ E.

Range in Characteristics

Profile: soil moisture—not continuously moist in all parts of the moisture control section for 90 to 120 cumulative days, primarily between February and May, and moisture control section is usually moist from July through December; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; depth to bedrock—more than 150 centimeters; clay content of the

argillic horizon—60 to 80 percent.

A1 horizon: color—N 2/0 or 10YR 2/2, 3/2, or 4/2; texture—silty clay loam, clay loam, silty clay, or clay; rock fragment content—0 to 10 percent, mostly pebbles and a few cobbles.

A2 horizon: color—10YR 3/1, 3/2, 3/3, or 4/3 or 7.5YR 3/4; rock fragment content—0 to 10 percent, mostly pebbles and a few cobbles.

Transitional horizons: AB, BA, A/B, or B/A horizons are present in some pedons.

B horizon: color of matrix—dominantly 7.5YR 5/6, 5/8, or 4/6 or 10YR 5/6 or 5/8 but ranges to 7.5YR 4/4, 10YR 6/8 or 4/4, or 5YR 4/6; color of mottles—2.5YR 3/6, 4/6, 4/8, or 5/8 or 5YR 4/6 or 5/8; structure—prismatic or subangular blocky; reaction—neutral to strongly acid.

Laolao Series

The Laolao series consists of moderately deep, well drained soils on volcanic uplands. These soils formed in residuum derived from andesitic marine tuff and tuffaceous sandstone. Slope is 0 to 60 percent. The mean annual precipitation is about 230 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic Class

Very fine, oxidic, isohyperthermic Udic Haplustalfs

Typical Pedon

Laolao clay, 5 to 15 percent slopes; under mixed grasses and trees on an east-facing slope of 8 percent.

A1—0 to 3 centimeters; dark reddish brown (5YR 3/3) clay, reddish brown (5YR 4/3) dry; strong medium granular structure; hard, friable, sticky and plastic; common very fine, fine, and medium roots; many fine interstitial pores; strongly acid (pH 5.3); abrupt smooth boundary.

A2—3 to 15 centimeters; dark reddish brown (5YR 3/4) clay, reddish brown (5YR 4/4) dry; common fine and medium patches of red (2.5YR 4/6) from the Bt1 horizon; moderate medium subangular blocky structure; hard, friable, very sticky and very plastic; common very fine and fine roots and few medium and coarse roots; many fine and medium and few coarse tubular pores and few fine interstitial pores; weak pressure faces on peds; strongly acid (pH 5.5); clear wavy boundary.

Bt1—15 to 40 centimeters; red (2.5YR 4/6) clay; common fine and medium patches of dark reddish brown (5YR 3/4) worm casts; moderate medium prismatic structure parting to moderate coarse subangular blocky; friable, very sticky and very plastic; common very fine and few fine exped roots; few very fine, fine, and medium tubular pores; root channels stained dark reddish brown; few thin clay films on ped faces and in pores; strong pressure faces on peds; medium acid (pH 5.7); diffuse smooth boundary.

Bt2—40 to 82 centimeters; red (2.5YR 4/6) clay; moderate medium prismatic structure parting to weak coarse subangular blocky; friable, very sticky and very plastic; few very fine roots; few very fine, fine, and medium pores; root channels stained dark reddish brown; few thin clay films on faces of peds and in pores; strong pressure faces on peds; medium acid (pH 5.7); clear wavy boundary.

Cr—82 centimeters; mixed red (2.5YR 4/6) and strong brown (7.5YR 4/6) saprolitic tuff; crushes to clay with many sand-sized white (10YR 8/1) grains; massive (tuffaceous rock structure); friable, sticky and plastic; few very fine roots; few very fine and fine pores; continuous thin clay films in pores; few sand-sized manganese modules and concretions and few manganese stains; medium acid (pH 5.6).

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; about 76 meters northwest of As Lito Road and 3 meters north of a private driveway, about 213 meters west of the intersection of As Lito Road and the road that passes through the southern part of Susupe swamp; lat. 15°7′45″ N. and long. 145°42′35″ E.

Range in Characteristics

Profile: soil moisture—usually dry in the moisture control section for 90 to 120 cumulative days, usually moist from July through December; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; depth to tuff—50 to 100 centimeters; clay content of argillic horizon—60 to 80 percent.

A horizon: color—2.5YR 2.5/2 or 3/4, 5YR 2.5/2, 3/2, 3/3, or 3/4, 7.5YR 3/1 or 3/2, or 10YR 3/3; texture—silty clay or clay; reaction—strongly acid to neutral; gravel content (on the surface)—0 to 10 percent.

B horizon: color—2.5YR 4/4 or 4/6, 5YR 4/4, or 7.5YR 4/4, 4/6, 5/6, or 6/8; reaction—medium acid to neutral; other features—sand and gravel-sized saprolitic flecks in lower part in some pedons.

C horizon: present in some pedons.

Cr horizon (saprolite): color—mixed (dominant matrix colors are similar to those of the B horizon. Subordinate colors commonly have high value and variable chroma. These subordinate colors commonly are present as discrete sand-sized saprolitic flecks and as thin bands); texture—crushes and rubs easily to clay loam, silty clay, or clay; consistence when moist—friable to very firm; gravel content—0 to 10 percent; reaction—medium acid to mildly alkaline; effervescence—slightly effervescent in some pedons.

Luta Series

The Luta series consists of very shallow, well drained permeable soils on plateaus. These soils formed in sediment overlying limestone. Slope is 0 to 30 percent. The mean annual precipitation is about 230 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic Class

Loamy, oxidic, nonacid, isohyperthermic Lithic Ustorthents

Typical Pedon

Luta cobbly clay loam, 0 to 5 percent slopes (fig. 13); under secondary forest on a 2 percent slope.

Oi—1 centimeter to 0; undecomposed acacia leaf litter; abrupt smooth boundary.

A1—0 to 2 centimeters; dark brown (7.5YR 3/2) cobbly clay loam, brown (7.5YR 4/2) dry; strong fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine, fine, and medium roots; many very fine interstitial pores; about 15 percent limestone cobbles, exposed on the surface; mildly alkaline (pH 7.4); abrupt smooth boundary.

A2—2 to 7 centimeters; dark brown (7.5YR 3/4) cobbly clay loam, brown (7.5YR 4/4) dry; weak fine subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many very fine and few coarse roots; common very fine and few fine tubular pores and common very fine interstitial pores; about 15 percent coarse fragments, mostly cobbles; mildly alkaline (pH 7.6); clear smooth boundary.

Bw—7 to 15 centimeters; brown (7.5YR 4/4) cobbly clay loam; massive; soft, very friable, slightly sticky and slightly plastic; many very fine, common fine, and few medium roots; common very fine and few fine tubular pores and many very fine interstitial pores; about 10 percent cobbles and 5 percent pebbles of

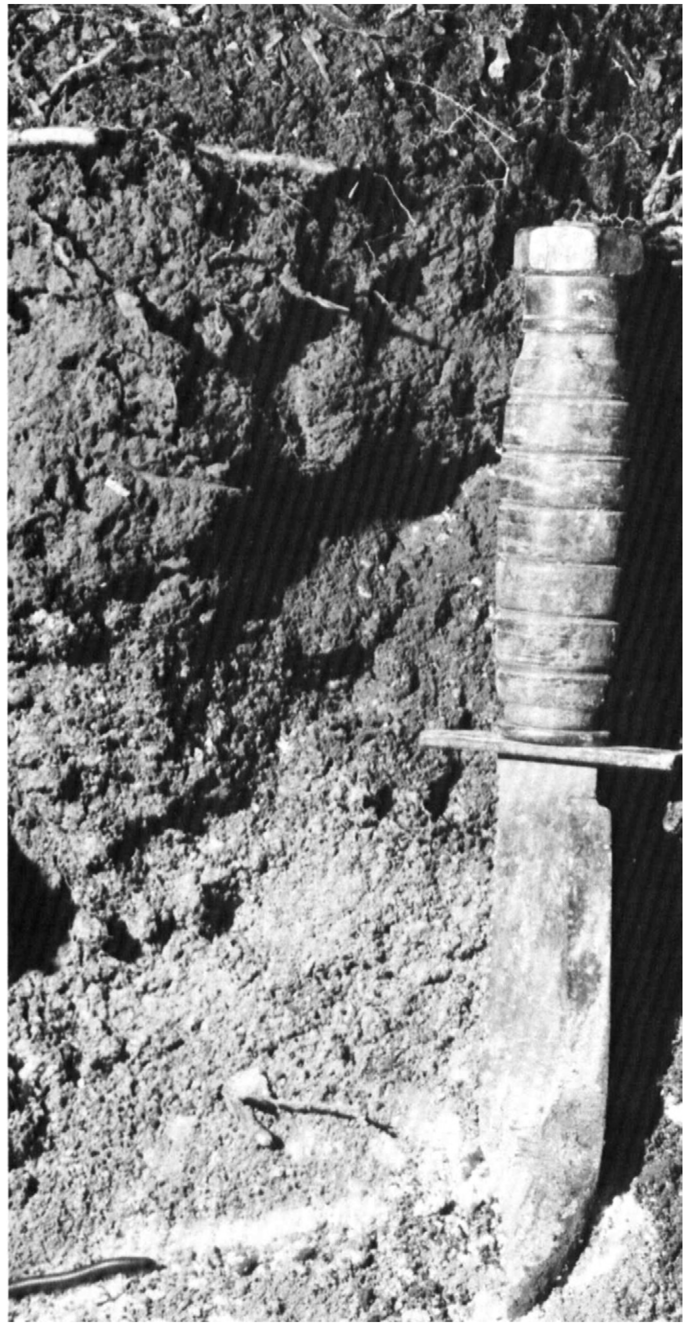

Figure 13.—Profile of Luta cobbly clay loam, 0 to 5 percent slopes. The upper 15 centimeters of limestone is soft; hard limestone is at a depth of about 30 centimeters.

limestone; neutral (pH 7.0); clear wavy boundary.

2Cr—15 to 30 centimeters; white (10YR 8/1) weathered limestone; stains of very pale brown (10YR 7/4) along pores and fractures; composed of cemented sand and coral fragments; few fine and medium roots along fractures; few fine and medium tubular pores and common very fine, fine, and medium interstitial pores; gradual wavy boundary.

2R—30 centimeters; white (10YR 8/1) unweathered limestone; hard and porous.

Type Location

Island of Rota, Commonwealth of the Northern Mariana Islands; in the Gampapa area, about 3 kilometers east-northeast of the airport, about 395 meters east of the main road, near a small farm field; lat. 14°10'35" N. and long. 145°16'15" E.

Range in Characteristics

Profile: soil moisture—usually dry for 90 to 120 cumulative days, usually moist from July through December; soil temperature—25 to 27 degrees C, with less than 2 degrees variation between summer and winter; profile depth—10 to 25 centimeters; depth to soft rock—10 to 25 centimeters; depth to hard bedrock—10 to 50 centimeters; clay content—20 to 35 percent; sand content—25 to 45 percent; coarse fragment content (limestone)—15 to 35 percent (more than 50 percent is cobbles).

A horizon: color—dominantly 7.5YR 3/2 or 3/4 but ranges to 10YR 4/3 (a thin A1 horizon of 10YR 2/2 or 3/2 or 7.5YR 3/2 is common in forested areas but generally is absent in cultivated grassland areas); total thickness—5 to 15 centimeters; reaction—neutral or mildly alkaline.

B horizon: color—dominantly 7.5YR 4/4 but ranges to 4/6 or 5/6 (higher chroma and value commonly are present in pedons that have a thicker B horizon); texture—cobbly clay loam or cobbly loam; other features—B horizon is intermittent in many pedons and absent in some (a few thin pressure faces line tubular pores in the lower part of some of the thicker B layers).

Mesei Variant

The Mesei Variant consists of deep, very poorly drained soils on level parts of depressional areas. These soils formed in marine deposits, alluvium, and organic material. Slope is 0 to 2 percent. The mean annual precipitation is about 230 centimeters, and the mean annual temperature is about 27 degrees C.

Taxonomic Class

Loamy-skeletal, carbonatic, euic, isohyperthermic Terric Troposaprists

Typical Pedon

Mesei Variant muck, 0 to 2 percent slopes, under grasses and forbs. (When described, the water table was at the surface.)

Oa1—0 to 20 centimeters; black (5Y 2.5/2) muck; massive; many very fine and fine roots; slightly sticky and nonplastic; about 5 percent fiber after rubbing; mineral fraction is silty clay but is a minor component; neutral (pH 7.0); diffuse smooth boundary.

C1—20 to 40 centimeters; very dark gray (5Y 3/1) gravelly mucky clay loam; massive; slightly sticky and nonplastic; few very fine and fine roots; about 5 percent fiber after rubbing; about 20 percent mollusk and coral pebbles; slightly effervescent; mildly alkaline (pH 7.6); diffuse smooth boundary.

C2—40 to 60 centimeters; dark olive gray (5Y 3/2) gravelly mucky sandy loam; massive; nonsticky and nonplastic; few very fine roots; less than 5 percent fiber after rubbing; about 30 percent mollusk and coral pebbles; strongly effervescent; mildly alkaline (pH 7.6); clear smooth boundary.

2Cg—60 to 100 centimeters; gray (5Y 5/1) very gravelly sandy loam; single grain; nonsticky and nonplastic; no roots; about 50 percent mollusk and coral pebbles; strongly effervescent; mildly alkaline (pH 7.6).

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; in the northern part of Susupe Marsh, about 0.8 kilometer southeast of central San Jose Village; lat. 15°9'30" N. and long. 145°42'40" E.

Range in Characteristics

Profile: soil moisture—permanently saturated to the surface; water table level—from 20 centimeters below the surface to more than 100 centimeters above the surface; soil temperature—25 to 29 degrees C, with little or no annual fluctuation; depth to 2Cg horizon—40 to 100 centimeters

O horizon: color—N 2/0, 5YR 2.5/1, 10YR 2/1 or 3/1, or 5Y 2.5/1, 2.5/2, 3/1, or 3/2; organic matter content—dominantly sapric, but many pedons contain thin layers of hemic material; mineral soil content—most layers contain minor amounts of sandy loam, silt

loam, clay loam, silty clay, or clay; gravel content—0 to 10 percent in the O horizon, 5 to 30 percent in the C1 horizon; mottles—present in some layers with higher mineral content, commonly have color of 5Y 4/1, 10YR 5/4, 7.5YR 4/4, or 5BG 4/1.

2Cg horizon: color—10YR 4/1 or 5Y 5/1; coarse fragment content—35 to 80 percent of angular mollusk and coral pebbles; other features—munitions and other metal fragments are present in some pedons.

Saipan Series

The Saipan series consists of deep, well drained soils on uplifted plateaus. These soils formed in sediment overlying porous coralline limestone. Slope is 0 to 30 percent. The mean annual precipitation is about 230 centimeters, and the mean annual temperature is about 27 degrees C.

Taxonomic Class

Fine, mixed, isohyperthermic Oxic Haplustalfs

Typical Pedon

Saipan clay in an area of Saipan clay, 5 to 15 percent slopes; under mixed native forest and agroforest on a southeast-facing slope of 8 percent.

A1—0 to 9 centimeters; dark brown (7.5YR 3/2) clay, dark brown (7.5YR 3/2) dry; strong very fine and fine subangular blocky structure; hard, firm, sticky and slightly plastic; common very fine, fine, and coarse roots; common very fine and fine tubular and interstitial pores; about 2 percent coral pebbles; soil is difficult to rub down; neutral (pH 7.0); abrupt smooth boundary.

A2—9 to 16 centimeters; dark reddish brown (5YR 3/3) clay, dark reddish brown (5YR 3/3) dry; strong very fine and fine subangular blocky structure; hard, firm, sticky and slightly plastic, common very fine, fine, and coarse roots and many medium roots; common very fine and fine interstitial pores and few fine tubular pores; few fine pieces of Bt1 material throughout horizon; neutral (pH 7.0); clear wavy boundary.

Bt1—16 to 48 centimeters; reddish brown (5YR 4/4) clay; moderate coarse subangular blocky structure parting to moderate fine and medium subangular blocky; very friable, sticky and plastic; common very fine, fine, and medium roots; common very fine, fine, and medium tubular pores; some pores are stained with organic material, and about half of them are oriented along vertical ped faces; common thin and moderately thick clay films on faces of peds and lining tubular pores; dark reddish brown (5YR 3/3) worm casts; neutral (pH 7.0); gradual wavy boundary.

Bt2—48 to 74 centimeters; reddish brown (5YR 4/4) clay; few fine patches of yellowish red (5YR 4/6); moderate coarse angular blocky structure parting to moderate fine and medium angular blocky; friable, sticky and plastic; few very fine and fine roots; few very fine and fine tubular pores; common moderately thick clay films on ped faces and lining tubular pores; very dark grayish brown (10YR 3/2) organic matter stains along most vertical root channels; fine manganese stains on about 3 percent of vertical ped faces; about 3 percent angular quartz sand grains; neutral (pH 7.0); gradual wavy boundary.

Bt3—74 to 107 centimeters; yellowish red (5YR 4/6) silty clay; moderate coarse angular blocky structure parting to moderate fine and medium angular blocky; friable, very sticky and plastic; few very fine and fine roots; few very fine and fine tubular pores; many moderately thick clay films lining pores; organic stains along most vertical root channels; fine manganese stains on about 3 percent of vertical ped faces; about 3 percent angular quartz sand grains; neutral (pH 7.2); gradual wavy boundary.

Bt4—107 to 120 centimeters; yellowish red (5YR 4/6) clay with strong brown (7.5YR 4/6) in a very coarse irregular pattern; moderate medium and coarse subangular blocky structure; friable, very sticky and plastic; few fine roots; few very fine and fine tubular pores; many moderately thick clay films on ped faces and lining tubular pores; about 3 percent very fine manganese concretions; organic stains along most vertical root channels; neutral (pH 7.2); abrupt smooth boundary.

2R—120 centimeters; white coralline limestone.

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; in the Francisco property, about 1 mile southeast of San Roque Village, at the end of jeep trail extending from the southern Kalabera area; lat. 15°14′15″ N. and long. 145°46′50″ E.

Range in Characteristics

Profile: soil moisture—not continuously moist in all parts of the moisture control section for 90 to 120 cumulative days, usually moist from July through

December; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; depth to limestone—100 centimeters to more than 200 centimeters; clay content of argillic horizon—35 to 60 percent; thickness of ochric epipedon—10 to 22 centimeters.

A horizon: color—5YR 3/3 or 3/4, 7.5YR 3/2 or 3/4, 10YR 2/2 or 3/2, or 2.5YR 2/2 or 3/2; texture—clay, silty clay, or silty clay loam; structure—granular or subangular blocky; rock fragment content—0 to 10 percent, mostly pebbles and a few cobbles; reaction—slightly acid to mildly alkaline.

B horizon: color—5YR 4/4 or 4/6, 7.5YR 4/6 or 5/6, or 2.5YR 4/6; texture—clay loam, silty clay, silty clay loam, or clay; structure—angular or subangular blocky; reaction—slightly acid to mildly alkaline.

Shioya Series

The Shioya series consists of very deep, excessively drained soils on coastal strands. These soils formed in water-deposited coral sand. Slope is 0 to 3 percent. The mean annual precipitation is about 220 centimeters, and the mean annual temperature is about 25 degrees C.

Taxonomic Class

Carbonatic, isohyperthermic Typic Ustipsamments

Typical Pedon

Shioya loamy sand, 0 to 3 percent slopes; in a level area in a coconut grove.

Oi—1 centimeter to 0; undecomposed leaves; covers about half of the soil surface.

A1—0 to 19 centimeters; very dark gray (10YR 3/1) loamy sand; single grain; loose, nonsticky and nonplastic; common very fine and fine roots and few medium roots; many very fine interstitial pores; violently effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

A2—19 to 35 centimeters; grayish brown (10YR 5/2) sand; single grain; loose, nonsticky and nonplastic; few very fine, fine, coarse, and very coarse roots; many very fine interstitial pores; violently effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

C1—35 to 80 centimeters; mixed very pale brown (10YR 7/3 and 8/3) sand, single grain; loose, nonsticky and nonplastic; few very fine, fine, coarse, and very coarse roots; many very fine interstitial pores; occasional pebble-sized shell and coral fragments; violently effervescent; moderately alkaline (pH 8.4); gradual smooth boundary.

C2—80 to 160 centimeters; very pale brown (10YR 7/3 and 8/3) sand; massive; slightly hard, friable, nonsticky and nonplastic; few very fine, fine, and medium roots; many very fine interstitial pores; 10 percent grayish brown (10YR 5/2) patches 5 to 10 millimeters in diameter; horizon is very weakly cemented with carbonates that are visible with hand lens; occasional pebble-sized shell and coral fragments; violently effervescent; moderately alkaline (pH 8.4); abrupt smooth boundary.

2R—160 centimeters; cemented sand; can be chipped with difficulty.

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; in San Jose, Oleai Village, about 350 meters east of the coastline; lat. 15°9′45″ N. and long. 145°42′33″ E.

Range in Characteristics

Profile: soil moisture—usually dry in the moisture control section for 90 to 120 cumulative days, usually moist from July through November; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; depth to contrasting material—more than 150 centimeters to very gravelly sand, cemented sand, or limestone.

A horizon: total thickness—10 to 35 centimeters; color—10YR 2/1, 3/1, 3/2, 3/3, 4/2, 4/3, or 5/2; texture—loamy sand, sand, or sandy loam; rock fragment content—1 to 10 percent pebbles and 0 to 5 percent cobbles.

C horizon: color—10YR 6/4, 7/2, 7/3, 7/4, 7/6, 8/3, or 8/4 or 2.5Y 7/2 or 7/4; texture—sand or loamy sand; rock fragment content at a depth of less than 100 centimeters—2 to 10 percent pebbles and 0 to 10 percent cobbles; rock fragment content below a depth of 100 centimeters—2 to 20 percent pebbles and 0 to 10 percent cobbles; other features—buried A horizon is present in some pedons, some pebbles are composed of cemented sand grains, weak carbonate cementation is not present in all pedons, some pedons are affected by a saline water table that is below a depth of 1 meter at high tide.

Takpochao Series

The Takpochao series consists of very shallow, well drained soils on plateaus, side slopes, and escarpments. These soils formed in sediment overlying

coralline limestone. Slope is 3 to 99 percent. The mean annual precipitation is about 220 centimeters, and the mean annual temperature is about 25 degrees C.

Taxonomic Class

Clayey-skeletal, kaolinitic, isohyperthermic Lithic Haplustolls

Typical Pedon

Takpochao very cobbly clay in an area of Takpochao-Rock outcrop complex, 15 to 30 percent slopes; under native forest on a north-facing slope of 28 percent.

Oi—2 centimeters to 0; undecomposed leaf litter.

A1—0 to 3 centimeters; black (N 2/0) very cobbly loam; strong very fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots and common medium roots; many very fine interstitial pores; about 30 percent limestone cobbles and 20 percent pebbles; neutral (pH 7.0); abrupt smooth boundary.

A2—3 to 18 centimeters; very dark grayish brown (10YR 3/2) very cobbly clay; strong very fine subangular blocky structure; slightly hard, friable, sticky and plastic; many very fine and fine and roots common medium roots; many very fine interstitial pores; about 20 percent cobbles and 20 percent pebbles; mildly alkaline (pH 7.4); clear broken boundary.

Bw—18 to 30 centimeters; dark yellowish brown (10YR 4/4) very cobbly clay; moderate very fine subangular blocky structure; hard, friable, very sticky and very plastic; many very fine roots and common fine and medium roots; common very fine and fine tubular pores; about 20 percent cobbles and 20 percent pebbles; mildly alkaline (pH 7.6); abrupt irregular boundary.

R—30 centimeters; unweathered white limestone.

Type Location

Saipan, Commonwealth of the Northern Mariana Islands; about 700 meters west-northwest of Bird Island, about 100 meters west of the road to the Bird Island overlook, along a small trail; lat. 15°15'30" N. and long. 145°48'15" E.

Range in Characteristics

Profile: soil moisture—usually dry for 90 to 120 cumulative days, usually moist from July through December; soil temperature—25 to 29 degrees C, with less than 2 degrees variation between summer and winter; mollic epipedon thickness—10 to 25 centimeters (epipedons that are 10 to 18 centimeters thick rest directly on the limestone); depth to bedrock—10 to 40 centimeters; clay content—35 to 50 percent.

A horizon: color—7.5YR 3/2 or 3/3, 10YR 2/1, 2/2, 3/1, or 3/2, or N 2/0; texture—cobbly loam or cobbly clay loam in upper part (mixed texture is cobbly clay loam or cobbly clay); rock fragment content—35 to 60 percent, about 50 percent cobbles and 50 percent pebbles (percentage of pebbles and cobbles on the surface commonly is much higher).

B horizon: color—5YR 3/4, 4/4, or 4/6, 7.5YR 3/4 or 4/6, or 10YR 4/3 or 4/4; texture—cobbly clay loam or cobbly clay; rock fragment content—35 to 60 percent, of which 50 percent is cobbles and 50 percent is pebbles; other features—intermittent buried horizons are present in some pedons.

Takpochao Variant

The Takpochao Variant consists of very shallow, excessively drained soils on coastal plateaus. These soils formed in water-deposited sand and residuum over limestone. Slope is 3 to 10 percent. The mean annual precipitation is about 230 centimeters, and the mean annual temperature is about 27 degrees C.

Taxonomic Class

Loamy-skeletal, carbonatic, isohyperthermic Lithic Haplustolls

Typical Pedon

Takpochao Variant very gravelly sandy loam in an area of Takpochao Variant-Shioya complex, 1 to 10 percent slopes, under secondary forest.

Oi—1 centimeter to 0; undecomposed forest litter.

A1—0 to 8 centimeters; black (10YR 2/1) very gravelly sandy loam, very dark gray (10YR 3/1) dry; weak very fine subangular blocky structure; soft, very friable, nonsticky and nonplastic; many roots; many very fine and fine interstitial pores; common worm casts; strongly effervescent; mildly alkaline (pH 7.8); clear smooth boundary.

A2—8 to 15 centimeters; very dark gray (10YR 3/1) very gravelly sandy loam, dark gray (10YR 4/1) dry; massive; soft, very friable, nonsticky and nonplastic; many very fine and fine roots and few medium and coarse roots; many very fine and fine interstitial pores; violently effervescent; mildly alkaline (pH 7.8); abrupt wavy boundary.

R—15 centimeters; white (10YR 8/1) unweathered

limestone composed of cemented sand and gravel; many fine interstitial pores; few fine fractures; stains and roots penetrate along fractures.

Type Location

Island of Rota, Commonwealth of the Northern Mariana Islands; about 3 kilometers (northeast) past Coconut Village along the north coastal road and 10 meters north of the road; lat. 14°11'35" N. and long. 145°13'35" E.

Range in Characteristics

Profile: soil moisture—usually dry in the moisture control section for 90 to 120 cumulative days, usually moist from July to December; soil temperature—25 to 30 degrees C, with less than 2 degrees variation between summer and winter; depth to bedrock—10 to 50 centimeters; coarse fragment content—40 to 70 percent, mostly pebbles and some cobbles.

A horizon: depth—10 to 30 centimeters; color—10YR 2/1, 3/1, or 3/2 or 7.5YR 3/2; reaction—mildly alkaline or moderately alkaline.

C horizon: present in some deeper pedons; color—hue of 10YR, chroma of 2, value of 4 to 6; texture—very gravelly or extremely gravelly sandy loam or loamy sand.

Formation of the Soils

Soil is a natural, three-dimensional body on the Earth's surface that supports or is capable of supporting plants. Physical and chemical processes have determined its morphology. These processes have resulted from the interaction of five factors: climate, living organisms, parent material, topography, and time. Differences among soils can be traced to differences in one or more of these factors. The following section discusses each of these factors and explains how their interactions have formed the soils in the survey area.

Climate

The climate in the Northern Marianas is uniformly warm and humid throughout the year, with distinct wet and dry seasons. Soils at the higher elevations on the islands are more moist and are slightly cooler than those at the lower elevations. The only place where this is significant is in the Sabana area on Rota. The Luta soils of the Sabana are moist for more days out of the year than are the Luta soils of lower elevations; however, the high-elevation Luta soils are indistinguishable from the low-elevation Luta soils, although their use and management is slightly different.

The high temperatures and precipitation in the Northern Marianas have resulted in a strong weathering regime. Physical and biological processes break down the parent material and release the products of this breakdown into the soil solution. Many of these weathering products recombine into more resistant, secondary minerals. Other soluble materials are leached out of the soil profile during the rainy season. Over time, only the most resistant primary minerals and the most stable secondary minerals remain in the soil.

Most of the well drained upland soils in the Northern Marianas, such as those of the Akina and Saipan series, are highly weathered and leached. Soluble bases such as calcium and magnesium have been leached from the soils. Primary minerals have weathered to release iron, silica, and aluminum. Iron has formed the stable secondary iron oxide minerals, which give these soils their characteristic red color. In the Akina soils, the silica and aluminum released from the primary rock minerals have recombined to form the secondary clay mineral kaolinite. Silica is more soluble in a limestone environment such as exists in the Saipan and, particularly, the Banaderu soils and is subject to leaching. Kaolinite is present in these soils, but aluminum has also formed stable hydroxides called gibbsite; thus, Akina soils are mainly kaolinite and iron oxides, and Saipan and Banaderu soils are mainly kaolinite, iron oxides, and gibbsite.

The high rainfall of the islands causes clay minerals to move from the surface layer into the subsoil. During the dry season, evapotranspiration exceeds precipitation and the soils dry out. As the soils dry, the clay particles are deposited in the pores and along the ped faces of the subsoil. After a long period of time, distinct clay films are formed. Clay films are most clearly expressed in the Akina and Laolao soils, but they are present in most of the soils in the survey area that have argillic horizons. Clay films are absent in the Luta soils and in a few others.

Living Organisms

This factor includes the effects of vegetation, animals, and man on the formation of the soils. Vegetation has a twofold effect on soils. Firstly, vegetation stabilizes sloping landscapes and helps to prevent massive soil movements such as slumping and erosion. This is a very important aspect of vegetation on sloping volcanic soils such as those of the Agfayan Variant and the Akina and Laolao series. Secondly, vegetation decomposes in the soil to form organic matter. This organic matter binds soil particles into stable aggregates, increases soil water-holding capacity and infiltration rates, and slowly releases soil nutrients over time.

In the Northern Marianas, the dark-colored surface layer of most soils are is 15 to 20 centimeters thick. In forested areas, the dark-colored surface layer can be subdivided into a thin granular horizon on top and a thicker, subangular blocky horizon below. This structural

difference is a result of the amount of organic matter present. The subangular blocky horizon has about 5 to 10 percent organic matter, whereas the granular upper layer has closer to 15 to 20 percent organic matter; thus, the soils on the islands generally are high in organic matter content. Dark colors commonly are associated with high organic matter content, but in the tropics this correlation is poor. For instance, lab data show that the relatively light colored surface layer of the Luta soils is more than 15 percent organic matter, which is a very high value. In the deeper, highly leached soils such as those of the Akina and Saipan series, organic matter provides most of the nutrients required for plant growth. This is why the exposed subsoil of these soils is difficult to vegetate.

The role of vegetation in soil and landscape development is most pronounced on the Akina soils in the Talufofo area of Saipan and the Talakhaya area of Rota. Akina soils formed in saprolitic tuff that has been deeply weathered to form clay. The continual downcutting of streams has created steep side slopes. Heavy rains saturate the clayey saprolite, and slumping occurs on the oversteepened side slopes. The resulting badland scars are subject to intensive erosion. Gradually, pioneering plant species such as manafern *(Gleichenia linearis)* become established on the badland and provide conditions for grasses and forbs to germinate and grow. Although the steep headwall of the badland may continue to slump, most of the badland will eventually "heal" under natural conditions and become a young savannah soil. If these savannah soils are stable over a long period of time, they develop into Akina soils. Shrubs such as chosgo *(Glochidion marianum)* and gafao *(Melastoma marianum)* may appear among the savannah grasses; trees such as kafo' *(Pandanus fragrans)* and gagu *(Casuarina equisetifolia)* may invade the site. Eventually, if there is no disruption from man or fire, or from further slumping, a forest will develop.

The effects of the forest vegetation on the soil is, in some ways, significantly different than those of the savannah. Very few slumps (badlands) can be observed on the forested Laolao soils. This may be due in part to the effective binding strength of the extensive woody tree roots. In addition, water lost from the forest system, both through runoff and infiltration, is substantially less than that lost from savannah *(11)*. Thus, the forest may be effectively "dewatering" the soil, thereby preventing the loss of strength and subsequent slumping that is common in the savannahs.

The Laolao and Akina soils are morphologically very similar, although the Laolao soils are yellower in hue. Chemically, however, the Akina soils are much lower in bases such as calcium and magnesium. In some areas the difference between Laolao and Akina soils is attributable to differences in parent material. In other areas, however, the differences may be attributable to vegetation. Akina soils are in savannah. Laolao soils are in forest or have been cleared and are capable of regenerating forest. It is possible that the savannah vegetation contributes to the low base status of the soils, because wildfires frequently burn the savannahs but do not burn the forest. As a result of the fire, all of the bases stored in the savannah vegetation are solubilized and deposited on the bare soil surface, which is subject to the intense leaching and erosive forces of the rainfall. This process does not occur in forested areas. The effects of fire, combined with the lower biomass production of the savannah and the higher runoff and leaching rates, may account for the presence of the low-base Akina soils in savannahs and the higher base Laolao soils in the forests; however, the possibility of the two soils differing with respect to parent material cannot be ignored.

The factor of the effects of living organisms on the soils of the Northern Mariana Islands includes the effects of man. General soil map unit 6 delineates those areas of the island that are effectively urbanized or have been extensively altered by human activities. The Chinen, Kagman, and Saipan series all have soils that have a very gravelly sandy loam surface layer. These soils have been covered with gravel fill in the past. Most areas now support tangantangan, but the gravel fill remains and is in effect a soil horizon deposited by man. In addition to the physical effects of bulldozing, scraping, spreading gravel, and pouring concrete, man affects the soils in many other ways. Most of the wildfires in the savannahs are attributable to man. These fires significantly affect soil erosion and plant succession. Off-road vehicles have a similar, although highly localized, effect.

Topography

Topography is the relief features or surface configuration of the landscape. Topography is the result of geologic forces such as uplift, folding, and faulting as well as geomorphic processes such as erosion and deposition.

Most of the uplifted volcanic landscapes of Saipan and Rota have been deeply dissected by rivers. The resulting topography includes many steep slopes. The Akina, Agfayan Variant, and Laolao soils, which occur on these slopes, are continually subject to erosion and

slumping. Thus, topography is in part responsible for the very shallow depth of the Agfayan Variant soils and the presence of badland slumps on the Akina soils.

Erosional products, or alluvium, from these soils are deposited in various positions downslope, depending on the topographic gradients and the flow of the alluvium-laden waters. The distribution and extent of the Inarajan soils and many areas of Kagman soils are related to their topographic positions in relation to the surrounding uplands. In some areas of Saipan and Kagman soils, the accumulation of sediment as a result of slopewash and surface creep has been very gradual. These areas commonly are on midslope benches or on broad plateaus at the base of extensive uplands.

Many areas of the deep Kagman and Saipan soils are on upland benches with little or no upslope sediment source. The Carolinas area on Tinian and the upper plateau of Aguijan are examples. The topographic stability of these areas has allowed the sediment to accumulate and remain in place without erosional losses. Where slopes are more than 30 percent, only the very shallow Takpochao soils occur.

The distribution of the sandy Shioya soils is directly related to topography. Only in those areas that are subject to sand deposition can Shioya soils form.

Internal drainage is an important soil characteristic related to topographic position. During the rainy season, soils in low topographic positions receive runoff from higher lying areas. In slowly permeable, nearly level soils this creates a seasonal or permanent high water table. The Inarajan soils have a seasonal high water table, and the Mesei Variant soils have a permanent high water table. Under natural conditions the Chacha soils have a seasonal high water table, but most areas have been artificially drained. The presence of a high water table has an enormous influence on soil development. In mineral soils such as those of the Inarajan series, montmorillonitic clay tends to form or persist. Mottles in the soil are evidence that these soils are wet during the rainy season. Reddish mottles are in areas where iron has accumulated, and dull gray mottles are in areas where iron has been removed. In the Chacha soils, manganese concretions are evidence that these soils are or have been seasonally wet.

Parent Material

Parent material is an important soil forming factor in the Northern Marianas, and it accounts for many of the differences among soils. Most of the geological information about Saipan is from Cloud et al. *(3)*, most information about Tinian is from Doan et al. *(4)*, and most of the information about Rota is from Sugawara *(14)*. No information is available on the geology of Aguijan.

Saipan, Tinian, and Rota all have a volcanic core, upon and around which limestone has been deposited. Presumably, Aguijan has a similar origin, although no volcanic materials are exposed. The volcanic deposition occurred during the Eocene and, on Saipan, the Oligocene. The material is mainly andesitic, with the notable exception of the dacitic Sankakuyama Formation on Saipan. Some of the material was deposited subaerially (in air or out of the ocean) as tuff and tuff breccia, and for the dacite, as pyroclastic flows. Other volcanic depositions were submarine, and they occur as various conglomerates, tuffaceous sandstones, and calcareous tuffs. On Saipan, the oldest unit is the dacitic Sankakuyama Formation, followed by the andesitic Hagman and Densinyama Formations. The volcanics on Rota are thought to be contemporaneous with the Hagman Formation, and the Tinian volcanics are undifferentiated. All are Eocene. The youngest volcanic formation, the Fina-Sisu Formation on Saipan, is of Oligocene age. The limestones range from the late Eocene Matansa Formation to the Pleistocene Tanapag Formation. By far the major limestone formations are the Miocene Tagpochau Formation and the Pleistocene Mariana Formation. The Tagpochau Formation contains a bewildering array of facies, many of which are heavily influenced by volcanic material. The Donni Sandstone member of the Tagpochau Formation on Saipan is of particular significance to soil genesis. The younger Mariana Limestone is primarily a coral reef complex and detritus. During the Holocene the lowland alluvium and strandline sediments were deposited, and they continue to be deposited.

The Agfayan Variant soils of northern Saipan, in the Achugao and Bird Island areas, have developed from the dacites of the Sankakuyama Formation. Because of this, these soils are high in quartz and glass sand. The dacites are quite resistant to weathering, and as a result the Agfayan Variant soils are very shallow. Agfayan Variant soils also occur over an outcropping at the tip of the Kagman Peninsula that is mapped as the Hagman Formation. This outcropping is harder and more resistant to weathering than other areas of the Hagman Formation.

As discussed in the section "Living Organisms," the Akina and Laolao soils are similar except for their base status; Laolao soils have a moderate amount of bases, whereas Akina soils are low in bases. This may be due in part to the facies in which they formed. Akina soils generally occur over the Hagman Formation, whereas

Laolao soils occur over the Fina-Sisu Formation as well as the Donni Sandstone facie of Tagpochau Limestone. Both soils, however, occur over the andesitic Densinyama Formation. It is possible that the subaqueous, more calcareous facies of the Densinyama Formation weather to form Laolao soils, whereas the subaerial, less calcareous facies weather to form Akina soils. It is likely that these parent material differences have resulted in mineralogical differences as well. Data on Akina soils on Guam indicate that the main aluminosilicate clay mineral is kaolinite. Earlier work on Saipan *(8)* indicates that montmorillonite is the dominant clay mineral in the Laolao soils. McCracken referred to this montmorillonitic pedon as Akina soils. We have revised the concept of the Akina series to better suit modern uses and soil classification systems; the typical pedon is now within the Laolao range of characteristics.

There are no clear correlations between specific limestone formations and specific soils. Certain soils, such as those of the Banaderu, Chinen, Dandan, Luta, and Takpochao series, occur only over limestone, but each can occur over any of the limestones. For instance, Banaderu soils are over Tagpochau Limestone on Saipan and over Mariana Limestone on Tinian. Takpochao soils occur over the oldest limestone (Matansa) to the youngest limestone (Tanapag). Luta soils occur only on Rota, but they cover the entire spectrum of limestones there. The only good correlation between a limestone facie and a specific soil series is that between Donni Sandstone and the Laolao soils. Donni Sandstone is a tuffaceous sandstone that can be considered as transitional between limestone and volcanic rock.

As indicated in the case of the Donni Sandstone, the purity of a limestone is an important determinant of the soil that weathers from it. A "pure" limestone weathers to carbon dioxide and water saturated with calcium carbonate. Thus, the impurities in the limestone constitute the residual limestone soil. With the exception of the Donni Sandstone, geologic mapping on Saipan did not distinguish between the purity of the limestones in the different map units. On Tinian, argillaceous facies of limestone were not correlated with a change in the kind of soil. In many areas the limestone is exceptionally pure; analyses of the material underlying the typical pedon of the Luta soils indicate that the limestone is essentially 100 percent pure. If much of the limestone is pure, and soils do not change as the limestone becomes less pure, then it is possible that the soils did not form from the underlying limestone.

Further evidence for this is the abrupt, irregular boundaries between the soil and the underlying hard, unweathered limestone. It is possible that the soil material was deposited as ashfall from volcanoes, although the location of these hypothetical volcanoes remains a mystery. There is, however, an active volcano (Mount Esmiralda) off the coast of Tinian, presently about 20 meters below the ocean surface. Another possibility is the deposition of erosional products from the volcanic uplands, either into the lagoons or marine environments prior to uplift or directly onto the limestone surfaces. This is certainly the case in some areas, particularly on Saipan; however, it is a weak explanation for the presence of deep soils on the top plateau of Aguijan, where no volcanic outcroppings are present. Research is needed to determine the parent material of the Banaderu, Chinen, Dandan, Luta, and other soils derived from limestone.

Alluvium is an important parent material, particularly downslope from the uplifted, tilted, and strongly dissected volcanic deposits of Saipan, Rota, and, to a lesser extent, Tinian. The Inarajan soils formed in alluvium. Most of the Kagman soils on Saipan, and many areas of the Saipan soils, formed at least in part in alluvial slopewash from surrounding uplands.

The Shioya soils and the Takpochao Variant soils on Rota formed in sands. These sands are beach deposits derived from limestone that has been physically weathered to sand and deposited along the coast by waves and currents. Wind was probably not an important depositional force, because no dunes are present.

Organic material, underlain by unconsolidated lagoon deposits, is the parent material of the Mesei Variant soils in Susupe swamp. Over thousands of years, karisu (*Phragmites karka*) have deposited leaves, stems, and roots in the swamp waters. Because of the anaerobic conditions created by the permanent high water table, the rate of organic-matter deposition is faster than the rate of decomposition, and therefore organic matter has accumulated.

Time

Soil development, by human standards, is a slow process. Time is necessary for rock to weather into soils and for soils to develop distinct horizons. In some soils erosion keeps pace with the weathering of rock so that the soils are always young. This is part of the reason why the Agfayan Variant soils are so shallow and lack subsoil development. In other areas deposition occasionally replenishes the soils. This is true of the youthful Inarajan soils.

In terms of soil development, time moves quickly in

the tropics. High rainfall and constant high temperatures have resulted in relatively rapid soil development on the stable topographic positions in the Northern Marianas. The Saipan soils have physical and chemical properties that can only develop over a long period of time. Even the Akina soils, although not on a particularly stable landscape, have properties of leaching and weathering that are associated with those of an "old" soil.

Generally, the age of the parent material is related to the age and subsequent development of the corresponding soil. In many places the relative age of the different landscape units, or geomorphic surfaces, is directly related to differences in soil development. In the Northern Marianas, one would expect to find deeper and more strongly developed soils on the older limestone terraces than on the younger ones. This appears to be the case on Aguijan, where the soils are deeper on the upper (older) terraces; however, this relationship does not hold on Saipan, Tinian, and Rota. In fact, the uniformity of soils across limestone of different ages is good evidence that the soils are all of the same age and have developed in materials deposited on top of the limestone.

The relationship between the age of the parent material and the age of the corresponding soil is poor for the volcanics as well. The oldest formation on Saipan, the Sankakuyama Formation, also happens to be the most resistant to weathering. The resulting Agfayan Variant soils are shallower and less developed than the Akina and Laolao soils on younger formations. Thus, although time has been an important soil-forming factor on the islands, the relative age of the geologic formations does not consistently predict soil development.

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Glossary

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Andesite. Fine grained, extrusive volcanic rock of intermediate silica content.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Argillaceous limestone. Limestone containing an appreciable (but less than 50 percent) amount of clay.

Association, soil. A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as centimeters of water per centimeter of soil. The capacity, in centimeters, in a 150-centimeter profile or to a limiting layer is expressed as—

Very low	0 to 8
Low	8 to 15
Moderate	15 to 23
High	23 to 30
Very high	More than 30

Basalt. Fine grained extrusive volcanic rock of low silica content.

Base saturation. The degree to which material having cation exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bottom land. The normal flood plain of a stream, subject to flooding.

Breccia. Coarse grained clastic rock composed of large, angular, and broken rock fragments that are cemented together in a fine grained matrix.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Canopy. The leafy crown of trees or shrubs. (See Crown.)

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter, in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Coarse fragments. Mineral or rock particles larger than 2 millimeters in diameter.

Coarse textured soil. Sand or loamy sand.

Cobble (or cobblestone). A rounded or partly rounded fragment of rock 7.6 to 25 centimeters in diameter.

Cobbly soil material. Material that is 15 to 35 percent, by volume, rounded or partially rounded rock fragments 7.5 to 25 centimeters in diameter. Very cobbly soil material is 35 to 60 percent of these

rock fragments, and extremely cobbly soil material is more than 60 percent.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex, soil. A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Compressible (in tables). Excessive decrease in volume of soft soil under load.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conglomerate. A coarse grained, clastic rock composed of rounded to subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer material. Conglomerate is the consolidated equivalent of gravel.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—Readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—Adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 25 centimeters and 100 or 200 inches.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management. Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system. Growing crops using a planned system of rotation and management practices.

Cross-slope farming. Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown. The upper part of a tree or shrub, including the living branches and their foliage.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Detritus. Loose rock and mineral material that is worn off or removed directly by mechanical means and moved from its place of origin.

Dissection. The work of streams in cutting or dividing the land into hills and ridges, or into flat upland areas, separated by fairly close networks of valleys.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—These soils have very high and high hydraulic conductivity and low water holding capacity. They are not suited to crop production unless irrigated.

Somewhat excessively drained.—These soils have high hydraulic conductivity and low water holding capacity. Without irrigation, only a narrow range of crops can be grown and yields are low.

Well drained.—These soils have intermediate water holding capacity. They retain optimum amounts of moisture, but they are not wet close enough to the surface or long enough during the growing season to adversely affect yields.

Moderately well drained.—These soils are wet close enough to the surface or long enough that planting or harvesting operations or yields of some field crops are adversely affected unless artificial drainage is provided. Moderately well drained soils commonly have a layer with low hydraulic conductivity, a wet layer relatively high in the profile, additions of water by seepage, or some combination of these.

Somewhat poorly drained.—These soils are wet close enough to the surface or long enough that planting or harvesting operations or crop growth is markedly restricted unless artificial drainage is provided. Somewhat poorly drained soils commonly have a layer with low hydraulic conductivity, a wet layer high in the profile, additions of water through seepage, or a combination of these.

Poorly drained.—These soils commonly are so wet at or near the surface during a considerable part of the year that field crops cannot be grown under natural conditions. Poorly drained conditions are caused by a saturated zone, a layer with low hydraulic conductivity, seepage, or a combination of these.

Very poorly drained.—These soils are wet to the surface most of the time. They are wet enough to prevent the growth of important crops (except rice) unless artificially drained.

Drainage, surface. Runoff, or surface flow of water, from an area.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature; for example, fire that exposes the surface.

Escarpment. A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and produced by erosion or faulting. Synonym: scarp.

Excess fines (in tables). Excess silt and clay in the soil. The soil does not provide a source of gravel or sand for construction purposes.

Extrusive rock. Igneous rock derived from deep-seated molten matter (magma) emplaced on the earth's surface.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Fine textured soil. Sandy clay, silty clay, and clay.

Firebreak. Area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of men and equipment in fire fighting. Designated roads also serve as firebreaks.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Forb. Any herbaceous plant not a grass or a sedge.

Forest type. A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Gravel. Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Green manure crop (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard rock. Rock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual*. The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, the number 2 precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Igneous rock. Rock formed by solidification from a molten or partially molten state. Major varieties include plutonic and volcanic rock. Examples are andesite, basalt, and granite.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Drip (or trickle).—Water is applied slowly and

under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Karst (topography). The relief of an area underlain by limestone that dissolves in differing degrees, thus forming numerous depressions or small basins.

Leaching. The removal of soluble material from soil or other material by percolating water.

Light textured soil. Sand and loamy sand.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Muck. Dark colored, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color in hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil, adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	Less than 0.06 centimeter
Slow	0.06 to 0.2 centimeter
Moderately slow	0.2 to 0.6 centimeter
Moderate	0.6 inch to 2.0 centimeters
Moderately rapid	2.0 to 6.0 centimeters
Rapid	6.0 to 20 centimeters
Very rapid	More than 20 centimeters

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Plateau. An extensive upland mass with relatively flat summit area that is considerably elevated (more

than 100 meters) above adjacent lowlands and separated from them on one or more sides by escarpments.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. The water can be removed only by percolation or evapotranspiration.

Poor filter (in tables). Because of rapid permeability or an impermeable layer near the surface, the soil may not adequately filter effluent from a waste disposal system.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Road cut. A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Root zone. The part of the soil that can be penetrated by plant roots.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone. Sedimentary rock containing dominantly sand-size particles.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saprolite (soil science). Unconsolidated residual material underlying the soil and grading to hard bedrock below.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and runoff water.

Shrink-swell (in tables). The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil

that is 80 percent or more silt and less than 12 percent clay.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 meters in 100 meters of horizontal distance.

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Slow intake (in tables). The slow movement of water into the soil.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

Small stones (in tables). Rock fragments less than 3 inches (7.5 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	Less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 6 to 15 inches (15 to 38 centimeters) in length if flat.

Strand. Refers to shore or beach.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling. Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum. The part of the soil below the solum.

Subsurface layer. Technically, the E horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Summer fallow. The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand,

loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Toxicity (in tables). Excessive amount of toxic substances, such as sodium or sulfur, that severely hinder establishment of vegetation or severely restrict plant growth.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Tuff. A compacted deposit that is 50 percent or more volcanic ash and dust.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Tables

TABLE 1.--HECTARAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Aguijan	Rota	Saipan	Tinian	Total-- Area	Total-- Extent
		Hectares	Hectares	Hectares	Hectares	Hectares	Pct
1	Agfayan Variant-Rock outcrop complex, 15 to 30 percent slopes	0	0	29	0	29	0.1
2	Agfayan Variant-Rock outcrop complex, 30 to 60 percent slopes	0	0	124	0	124	0.4
3	Akina-Badland complex, 15 to 30 percent slopes	0	2	80	0	82	0.3
4	Akina-Badland complex, 30 to 60 percent slopes	0	61	332	0	393	1.2
5	Banaderu clay loam, 3 to 5 percent slopes	0	0	38	199	237	0.8
6	Banaderu clay loam, 5 to 15 percent slopes	0	0	88	0	88	0.3
7	Banaderu-Rock outcrop complex, 5 to 15 percent slopes	0	0	23	4	27	0.1
8	Banaderu-Rock outcrop complex, 15 to 30 percent slopes	0	0	93	0	93	0.3
9	Chacha clay, drained, 0 to 5 percent slopes	0	0	112	10	122	0.4
10	Chinen clay loam, 0 to 5 percent slopes	129	0	849	881	1,859	5.9
11	Chinen clay loam, 5 to 15 percent slopes	77	23	1,511	766	2,377	7.6
12	Chinen clay loam, 15 to 30 percent slopes	0	43	1,436	87	1,566	5.0
13	Chinen very gravelly sandy loam, 0 to 5 percent slopes	0	0	546	435	981	3.1
14	Chinen very gravelly sandy loam, 5 to 15 percent slopes	0	0	149	35	184	0.6
15	Chinen-Rock outcrop complex, 3 to 15 percent slopes	28	0	170	289	487	1.5
16	Chinen-Rock outcrop complex, 15 to 30 percent slopes	0	0	149	93	242	0.8
17	Chinen-Urban land complex, 0 to 5 percent slopes	3	0	476	1,064	1,543	4.9
18	Chinen-Urban land complex, 5 to 15 percent slopes	0	0	78	11	89	0.3
19	Dandan-Chinen complex, 0 to 5 percent slopes	0	0	0	3,011	3,011	9.6
20	Dandan-Chinen complex, 5 to 15 percent slopes	18	56	0	746	820	2.6
21	Dandan-Chinen-Pits complex, 0 to 5 percent slopes	0	0	0	149	149	0.5
22	Dandan-Chinen-Pits complex, 5 to 15 percent slopes	0	0	0	44	44	0.1
23	Dandan-Saipan clays, 0 to 5 percent slopes	0	0	0	297	297	0.9
24	Dandan-Saipan clays, 5 to 15 percent slopes	0	0	0	51	51	0.2
25	Inarajan clay, 0 to 5 percent slopes	0	0	68	1	69	0.2
26	Kagman clay, 0 to 5 percent slopes	0	0	304	188	492	1.6
27	Kagman clay, 5 to 15 percent slopes	0	0	346	69	415	1.3
28	Kagman very gravelly sandy loam, 0 to 5 percent slopes	0	0	112	0	112	0.4
29	Kagman-Urban land complex, 0 to 5 percent slopes	0	0	31	0	31	0.1
30	Laolao clay, 0 to 5 percent slopes	0	0	0	29	29	0.1
31	Laolao clay, 5 to 15 percent slopes	0	49	321	88	458	1.5
32	Laolao clay, 15 to 30 percent slopes	0	16	413	0	429	1.4
33	Laolao clay, 30 to 60 percent slopes	0	75	165	10	250	0.8
34	Luta cobbly clay loam, 0 to 5 percent slopes	0	2,358	0	0	2,358	7.5
35	Luta cobbly clay loam, 5 to 15 percent slopes	0	1,584	0	0	1,584	5.0
36	Luta cobbly clay loam, moist, 0 to 5 percent slopes	0	313	0	0	313	1.0
37	Luta cobbly clay loam, moist, 5 to 15 percent slopes	0	18	0	0	18	0.1
38	Luta-Rock outcrop complex, 0 to 5 percent slopes	0	557	0	0	557	1.8
39	Luta-Rock outcrop complex, 5 to 15 percent slopes	0	1,277	0	0	1,277	4.1
40	Luta-Rock outcrop complex, 15 to 30 percent slopes	0	604	0	0	604	1.9
41	Mesei Variant muck, 0 to 2 percent slopes	0	0	192	13	205	0.7
42	Rock outcrop-Takpochao complex, 60 to 99 percent slopes	32	406	458	167	1,063	3.4
43	Saipan clay, 0 to 5 percent slopes	0	0	428	141	569	1.8
44	Saipan clay, 5 to 15 percent slopes	0	0	439	22	461	1.5
45	Saipan very gravelly sandy loam, 0 to 5 percent slopes	0	0	99	12	111	0.4
46	Saipan very gravelly sandy loam, 5 to 15 percent slopes	0	0	36	0	36	0.1
47	Saipan-Rock outcrop complex, 0 to 5 percent slopes	67	0	0	0	67	0.2

TABLE 1.--HECTARAGE AND PROPORTIONATE EXTENT OF THE SOILS--Continued

Map symbol	Soil name	Aguijan	Rota	Saipan	Tinian	Total-- Area	Total-- Extent
		Hectares	Hectares	Hectares	Hectares	Hectares	Pct
48	Shioya loamy sand, 0 to 3 percent slopes	0	6	320	151	477	1.5
49	Shioya-Urban land complex, 0 to 3 percent slopes	0	16	251	5	272	0.9
50	Takpochao-Rock outcrop complex, 3 to 15 percent slopes	210	132	319	607	1,268	4.0
51	Takpochao-Rock outcrop complex, 15 to 30 percent slopes	80	0	739	316	1,135	3.6
52	Takpochao-Rock outcrop complex, 30 to 60 percent slopes	74	500	726	185	1,485	4.7
53	Takpochao Variant-Shioya complex, 1 to 10 percent slopes	0	425	0	0	425	1.3
	Water	0	0	15	0	15	*
	Total	718	8,521	12,065	10,176	31,480	100.0

* Less than 0.1 percent.

TABLE 2.--CAPABILITY CLASSES AND SUBCLASSES

(All soils are assigned to nonirrigated capability subclasses. Only potentially irrigable soils are assigned to irrigated subclasses. Miscellaneous areas are excluded. Dashes indicate no hectarage)

Class	Total hectarage	Major management concerns (subclass)		
		Erosion (e)	Wetness (w)	Soil problem (s)
		Hectares	Hectares	Hectares
I (Nonirrigated):				
Aguijan	---	---	---	---
Rota	---	---	---	---
Saipan	---	---	---	---
Tinian	---	---	---	---
I (Irrigated):				
Aguijan	---	---	---	---
Rota	---	---	---	---
Saipan	---	---	---	---
Tinian	---	---	---	---
II (Nonirrigated):				
Aguijan	55	---	---	55
Rota	---	---	---	---
Saipan	932	---	180	752
Tinian	2,372	---	11	2,361
II (Irrigated):				
Aguijan	---	---	---	---
Rota	---	---	---	---
Saipan	---	---	---	---
Tinian	---	---	---	---
III (Nonirrigated):				
Aguijan	140	10	---	130
Rota	31	31	---	---
Saipan	1,934	785	---	1,149
Tinian	3,527	573	---	2,954
III (Irrigated):				
Aguijan	---	---	---	---
Rota	---	---	---	---
Saipan	---	---	---	---
Tinian	---	---	---	---
IV (Nonirrigated):				
Aguijan	102	---	---	102
Rota	5,806	49	---	5,757
Saipan	3,450	321	---	3,129
Tinian	2,223	88	---	2,135
IV (Irrigated):				
Aguijan	---	---	---	---
Rota	---	---	---	---
Saipan	---	---	---	---
Tinian	---	---	---	---
V (Nonirrigated):				
Aguijan	---	---	---	---
Rota	---	---	---	---
Saipan	---	---	---	---
Tinian	---	---	---	---

TABLE 2.--CAPABILITY CLASSES AND SUBCLASSES--Continued

Class	Total hectarage	Major management concerns (subclass)		
		Erosion (e)	Wetness (w)	Soil problem (s)
		Hectares	Hectares	Hectares
VI (Nonirrigated):				
Aguijan	---	---	---	---
Rota	440	440	---	---
Saipan	2,181	2,069	---	112
Tinian	146	146	---	---
VII (Nonirrigated):				
Aguijan	217	---	---	217
Rota	932	115	---	817
Saipan	1,854	462	192	1,200
Tinian	716	10	13	693
VIII (Nonirrigated):				
Aguijan	---	---	---	---
Rota	---	---	---	---
Saipan	---	---	---	---
Tinian	---	---	---	---

TABLE 3.--WOODLAND MANAGEMENT AND PRODUCTIVITY

(Only the soils suitable for production of commercial trees are listed. Absence of an entry indicates that information was not available)

Soil name and map symbol	Management concerns					Common trees	Trees to plant
	Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition		
3*:							
Akina	Moderate	Moderate	Slight	Moderate	Severe	---	Norfolk Island pine, Honduras mahogany.
Badland.							
4*:							
Akina	Severe	Severe	Slight	Moderate	Severe	---	Norfolk Island pine, Honduras mahogany.
Badland.							
5, 6 Banaderu	Slight	Slight	Slight	Severe	Severe	---	---
7*:							
Banaderu	Slight	Slight	Slight	Severe	Severe	---	---
Rock outcrop.							
8*:							
Banaderu	Moderate	Moderate	Slight	Severe	Severe	---	---
Rock outcrop.							
9 Chacha	Slight	Moderate	Slight	Moderate	Severe	---	---
10, 11 Chinen	Slight	Slight	Slight	Severe	Severe	---	---
12 Chinen	Moderate	Moderate	Slight	Severe	Severe	---	---
15*:							
Chinen	Slight	Slight	Slight	Severe	Severe	---	---
Rock outcrop.							
16*:							
Chinen	Moderate	Moderate	Slight	Severe	Severe	---	---
Rock outcrop.							
17*, 18*:							
Chinen	Slight	Slight	Slight	Severe	Severe	---	---
Urban land.							
19*, 20*:							
Dandan	Slight	Slight	Slight	Moderate	Severe	---	---
Chinen	Slight	Slight	Slight	Severe	Severe	---	---
21*, 22*:							
Dandan	Slight	Slight	Slight	Moderate	Severe	---	---

See footnote at end of table.

TABLE 3.--WOODLAND MANAGEMENT AND PRODUCTIVITY--Continued

Soil name and map symbol	Management concerns					Common trees	Trees to plant
	Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition		
21*, 22*:							
Chinen	Slight	Slight	Slight	Severe	Severe	---	---
Pits.							
23*, 24*:							
Dandan	Slight	Slight	Slight	Moderate	Severe	---	---
Saipan	Slight	Moderate	Slight	Moderate	Severe	---	Pterocarpus indicus.
25 Inarajan	Slight	Moderate	Slight	Moderate	Severe	---	Pterocarpus indicus, eucalyptus deglupta.
26, 27 Kagman	Slight	Moderate	Slight	Moderate	Severe	---	Pterocarpus indicus.
29*:							
Kagman	Slight	Moderate	Slight	Moderate	Severe	---	Pterocarpus indicus.
Urban land.							
30 Laolao	Slight	Moderate	Slight	Slight	Severe	---	---
31 Laolao	Slight	Moderate	Slight	Slight	Severe	---	---
32 Laolao	Moderate	Moderate	Slight	Slight	Severe	---	---
33 Laolao	Severe	Severe	Slight	Slight	Severe	---	---
34, 35, 36, 37 Luta	Slight	Slight	Slight	Severe	Severe	---	---
38*, 39*:							
Luta	Slight	Slight	Slight	Severe	Severe	---	---
Rock outcrop.							
40*:							
Luta	Moderate	Moderate	Slight	Severe	Severe	---	---
Rock outcrop.							
41 Mesei Variant	Slight	Severe	Severe	Severe	Severe	---	---
43, 44 Saipan	Slight	Moderate	Slight	Moderate	Severe	---	Pterocarpus indicus.
47*:							
Saipan	Slight	Moderate	Slight	Moderate	Severe	---	Pterocarpus indicus.
Rock outcrop.							
48 Shioya	Slight	Slight	Moderate	Slight	Moderate	Alexandrian laurel	Spanish cedar.

See footnote at end of table.

TABLE 3.--WOODLAND MANAGEMENT AND PRODUCTIVITY--Continued

Soil name and map symbol	Management concerns					Common trees	Trees to plant
	Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition		
49*:							
Shioya------------	Slight	Slight	Moderate	Slight	Moderate	Alexandrian laurel----	Spanish cedar.
Urban land.							
53*:							
Takpochao Variant-	Slight	Moderate	Slight	Severe	Severe	---	---
Shioya------------	Slight	Slight	Moderate	Slight	Moderate	Alexandrian laurel----	Spanish cedar.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 4.--RECREATIONAL DEVELOPMENT

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated)

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
1*:					
Agfayan Variant	Severe: slope, large stones, depth to rock.	Severe: slope, large stones, depth to rock.	Severe: large stones, slope, small stones.	Moderate: large stones, too clayey, slope.	Severe: large stones, slope, depth to rock.
Rock outcrop.					
2*:					
Agfayan Variant	Severe: slope, large stones, depth to rock.	Severe: slope, large stones, depth to rock.	Severe: large stones, slope, small stones.	Severe: slope.	Severe: large stones, slope, depth to rock.
Rock outcrop.					
3*:					
Akina	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: too clayey, slope.	Severe: slope.
Badland.					
4*:					
Akina	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
Badland.					
5 Banaderu	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Severe: depth to rock.
6 Banaderu	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Slight	Severe: depth to rock.
7*:					
Banaderu	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Slight	Severe: depth to rock.
Rock outcrop.					
8*:					
Banaderu	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: slope.	Severe: slope, depth to rock.
Rock outcrop.					
9 Chacha	Moderate: too clayey.	Moderate: too clayey.	Moderate: slope, too clayey, depth to rock.	Moderate: too clayey.	Moderate: droughty, depth to rock, too clayey.
10 Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: too clayey.	Severe: depth to rock.

See footnote at end of table.

TABLE 4.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
11-------------------- Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock.
12-------------------- Chinen	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: slope, too clayey.	Severe: slope, depth to rock.
13-------------------- Chinen	Severe: small stones, depth to rock.	Severe: small stones, depth to rock.	Severe: small stones, depth to rock.	Severe: small stones.	Severe: small stones, depth to rock.
14-------------------- Chinen	Severe: small stones, depth to rock.	Severe: small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: small stones.	Severe: small stones, depth to rock.
15*:					
Chinen---------------	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock.
Rock outcrop.					
16*:					
Chinen---------------	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: slope, too clayey.	Severe: slope, depth to rock.
Rock outcrop.					
17*:					
Chinen---------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: too clayey.	Severe: depth to rock.
Urban land.					
18*:					
Chinen---------------	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock.
Urban land.					
19*:					
Dandan---------------	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Severe: too clayey.
Chinen---------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: too clayey.	Severe: depth to rock.
20*:					
Dandan---------------	Moderate: too clayey.	Moderate: too clayey.	Moderate: slope, too clayey.	Moderate: too clayey.	Severe: too clayey.
Chinen---------------	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock.

See footnote at end of table.

TABLE 4.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
21*:					
Dandan	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Severe: too clayey.
Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: too clayey.	Severe: depth to rock.
Pits.					
22*:					
Dandan	Moderate: too clayey.	Moderate: too clayey.	Moderate: slope, too clayey.	Moderate: too clayey.	Severe: too clayey.
Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock.
Pits.					
23*:					
Dandan	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Severe: too clayey.
Saipan	Moderate: too clayey.	Moderate: too clayey.	Moderate: slope, small stones, too clayey.	Moderate: too clayey.	Moderate: droughty, too clayey.
24*:					
Dandan	Moderate: too clayey.	Moderate: too clayey.	Moderate: slope, too clayey.	Moderate: too clayey.	Severe: too clayey.
Saipan	Moderate: slope, too clayey.	Moderate: slope, too clayey.	Severe: slope.	Moderate: too clayey.	Moderate: droughty, slope, too clayey.
25 Inarajan	Severe: flooding, too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
26 Kagman	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
27 Kagman	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
28 Kagman	Severe: small stones.	Severe: small stones.	Severe: small stones.	Severe: small stones.	Severe: small stones.
29*:					
Kagman	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
Urban land.					
30 Laolao	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.

See footnote at end of table.

TABLE 4.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
31-------------------- Laolao	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
32-------------------- Laolao	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: slope, too clayey.
33-------------------- Laolao	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey, slope.	Severe: slope, too clayey.
34-------------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: large stones, depth to rock.	Moderate: large stones.	Severe: depth to rock.
35-------------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: large stones, slope, depth to rock.	Moderate: large stones.	Severe: depth to rock.
36-------------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: large stones, depth to rock.	Moderate: large stones.	Severe: depth to rock.
37-------------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: large stones, slope, depth to rock.	Moderate: large stones.	Severe: depth to rock.
38*:					
Luta-----------------	Severe: depth to rock.	Severe: depth to rock.	Severe: large stones, depth to rock.	Moderate: large stones.	Severe: depth to rock.
Rock outcrop.					
39*:					
Luta-----------------	Severe: depth to rock.	Severe: depth to rock.	Severe: large stones, slope, depth to rock.	Moderate: large stones.	Severe: depth to rock.
Rock outcrop.					
40*:					
Luta-----------------	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: large stones, slope, depth to rock.	Moderate: large stones, slope.	Severe: slope, depth to rock.
Rock outcrop.					
41-------------------- Mesei Variant	Severe: flooding, ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding, flooding.	Severe: ponding, excess humus.	Severe: ponding, flooding, excess humus.

See footnote at end of table.

TABLE 4.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
42*:					
Rock outcrop.					
Takpochao	Severe: slope, too clayey, depth to rock.	Severe: slope, too clayey, depth to rock.	Severe: large stones, slope, small stones.	Severe: too clayey, slope.	Severe: slope, depth to rock, too clayey.
43 Saipan	Moderate: too clayey.	Moderate: too clayey.	Moderate: slope, small stones, too clayey.	Moderate: too clayey.	Moderate: droughty, too clayey.
44 Saipan	Moderate: slope, too clayey.	Moderate: slope, too clayey.	Severe: slope.	Moderate: too clayey.	Moderate: droughty, slope, too clayey.
45 Saipan	Severe: small stones.	Severe: small stones.	Severe: small stones.	Severe: small stones.	Severe: small stones.
46 Saipan	Severe: small stones.	Severe: small stones.	Severe: slope, small stones.	Severe: small stones.	Severe: small stones.
47*:					
Saipan	Moderate: too clayey.	Moderate: too clayey.	Moderate: slope, small stones, too clayey.	Moderate: too clayey.	Moderate: droughty, too clayey.
Rock outcrop.					
48 Shioya	Severe: flooding.	Severe: excess salt.	Severe: excess salt.	Moderate: too sandy.	Severe: excess salt, droughty.
49*:					
Shioya	Severe: flooding.	Severe: excess salt.	Severe: excess salt.	Moderate: too sandy.	Severe: excess salt, droughty.
Urban land.					
50*:					
Takpochao	Severe: too clayey, depth to rock.	Severe: too clayey, depth to rock.	Severe: large stones, slope, small stones.	Severe: too clayey.	Severe: depth to rock, too clayey.
Rock outcrop.					
51*:					
Takpochao	Severe: slope, too clayey, depth to rock.	Severe: slope, too clayey, depth to rock.	Severe: large stones, slope, small stones.	Severe: too clayey.	Severe: slope, depth to rock, too clayey.
Rock outcrop.					

See footnote at end of table.

TABLE 4.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
52*:					
Takpochao	Severe: slope, too clayey, depth to rock.	Severe: slope, too clayey, depth to rock.	Severe: large stones, slope, small stones.	Severe: too clayey, slope.	Severe: slope, depth to rock, too clayey.
Rock outcrop.					
53*:					
Takpochao Variant	Severe: flooding, small stones, depth to rock.	Severe: small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Slight	Severe: small stones, droughty, depth to rock.
Shioya	Severe: flooding.	Severe: excess salt.	Severe: excess salt.	Moderate: too sandy.	Severe: excess salt, droughty.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 5.--WILDLIFE HABITAT

(See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated)

Soil name and map symbol	Potential for habitat elements					Potential as habitat for--		
	Wild herbaceous plants	Hardwood trees	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
1*, 2*:								
Agfayan Variant	Good	Poor	Fair	Very poor.	Very poor.	Good	Poor	Very poor.
Rock outcrop.								
3*, 4*:								
Akina	Good	Fair	Good	Very poor.	Very poor.	Good	Fair	Very poor.
Badland.								
5, 6 Banaderu	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
7*, 8*:								
Banaderu	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Rock outcrop.								
9 Chacha	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
10, 11, 12 Chinen	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
13, 14 Chinen	Fair	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
15*, 16*:								
Chinen	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Rock outcrop.								
17*, 18*:								
Chinen	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Urban land.								
19*, 20*:								
Dandan	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Chinen	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
21*, 22*:								
Dandan	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Chinen	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.

See footnote at end of table.

TABLE 5.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements: Wild herbaceous plants	Hardwood trees	Shrubs	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
21*, 22*: Pits.								
23*, 24*: Dandan	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Saipan	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
25 Inarajan	Good	Good	Fair	Good	Good	Good	Good	Good.
26, 27 Kagman	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
28 Kagman	Fair	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
29*: Kagman	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Urban land.								
30, 31, 32, 33 Laolao	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
34, 35, 36, 37 Luta	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
38*, 39*, 40*: Luta	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Rock outcrop.								
41 Mesei Variant	Very poor.	Very poor.	Very poor.	Good	Good	Poor	Very poor.	Good.
42*: Rock outcrop.								
Takpochao	Poor	Good	Good	Very poor.	Very poor.	Poor	Good	Very poor.
43, 44 Saipan	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
45, 46 Saipan	Fair	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
47*: Saipan	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Rock outcrop.								

See footnote at end of table.

TABLE 5.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements: Wild herbaceous plants	Hardwood trees	Shrubs	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
48------------------ Shioya	Poor	Good	Fair	Very poor.	Very poor.	Poor	Good	Very poor.
49*:								
Shioya------------	Poor	Good	Fair	Very poor.	Very poor.	Poor	Good	Very poor.
Urban land.								
50*, 51*, 52*:								
Takpochao---------	Poor	Good	Good	Very poor.	Very poor.	Poor	Good	Very poor.
Rock outcrop.								
53*:								
Takpochao Variant-	Fair	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Shioya------------	Poor	Good	Fair	Very poor.	Very poor.	Poor	Good	Very poor.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 6.--BUILDING SITE DEVELOPMENT

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
1*, 2*:					
Agfayan Variant	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: large stones, slope, depth to rock.
Rock outcrop.					
3*, 4*:					
Akina	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
Badland.					
5 Banaderu	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
6 Banaderu	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
7*:					
Banaderu	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
Rock outcrop.					
8*:					
Banaderu	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength, slope.	Severe: slope, depth to rock.
Rock outcrop.					
9 Chacha	Moderate: depth to rock, too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Moderate: droughty, depth to rock, too clayey.
10 Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
11 Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
12 Chinen	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength, slope.	Severe: slope, depth to rock.

See footnote at end of table.

TABLE 6.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
13---------------- Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, low strength.	Severe: small stones, depth to rock.
14---------------- Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength.	Severe: small stones, depth to rock.
15*:					
Chinen-----------	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
Rock outcrop.					
16*:					
Chinen-----------	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength, slope.	Severe: slope, depth to rock.
Rock outcrop.					
17*:					
Chinen-----------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
Urban land.					
18*:					
Chinen-----------	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
Urban land.					
19*:					
Dandan-----------	Severe: depth to rock.	Moderate: shrink-swell, depth to rock.	Moderate: shrink-swell, depth to rock.	Severe: low strength.	Severe: too clayey.
Chinen-----------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
20*:					
Dandan-----------	Severe: depth to rock.	Moderate: shrink-swell, slope, depth to rock.	Severe: slope.	Severe: low strength.	Severe: too clayey.
Chinen-----------	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
21*:					
Dandan-----------	Severe: depth to rock.	Moderate: shrink-swell, depth to rock.	Moderate: shrink-swell, depth to rock.	Severe: low strength.	Severe: too clayey.

See footnote at end of table.

TABLE 6.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
21*:					
Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
Pits.					
22*:					
Dandan	Severe: depth to rock.	Moderate: shrink-swell, slope, depth to rock.	Severe: slope.	Severe: low strength.	Severe: too clayey.
Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock.
Pits.					
23*:					
Dandan	Severe: depth to rock.	Moderate: shrink-swell, depth to rock.	Moderate: shrink-swell, depth to rock.	Severe: low strength.	Severe: too clayey.
Saipan	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, low strength.	Moderate: droughty, too clayey.
24*:					
Dandan	Severe: depth to rock.	Moderate: shrink-swell, slope, depth to rock.	Severe: slope.	Severe: low strength.	Severe: too clayey.
Saipan	Moderate: too clayey, slope.	Moderate: shrink-swell, slope.	Severe: slope.	Moderate: shrink-swell, low strength, slope.	Moderate: droughty, slope, too clayey.
25 Inarajan	Severe: wetness.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Severe: too clayey.
26 Kagman	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.	Severe: too clayey.
27 Kagman	Moderate: too clayey, slope.	Severe: shrink-swell.	Severe: shrink-swell, slope.	Severe: shrink-swell, low strength.	Severe: too clayey.
28 Kagman	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.	Severe: small stones.
29*:					
Kagman	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.	Severe: too clayey.
Urban land.					

See footnote at end of table.

TABLE 6.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
30---------------- Laolao	Moderate: depth to rock, too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Severe: too clayey.
31---------------- Laolao	Moderate: depth to rock, too clayey, slope.	Moderate: shrink-swell, slope.	Severe: slope.	Severe: low strength.	Severe: too clayey.
32, 33------------ Laolao	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope, too clayey.
34---------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.
35---------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock.	Severe: depth to rock.
36---------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.
37---------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock.	Severe: depth to rock.
38*:					
Luta-------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.
Rock outcrop.					
39*:					
Luta-------------	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock.	Severe: depth to rock.
Rock outcrop.					
40*:					
Luta-------------	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.
Rock outcrop.					
41---------------- Mesei Variant	Severe: excess humus, ponding.	Severe: subsides, flooding, ponding.	Severe: subsides, flooding, ponding.	Severe: subsides, ponding, flooding.	Severe: ponding, flooding, excess humus.
42*:					
Rock outcrop.					
Takpochao--------	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength, slope.	Severe: slope, depth to rock, too clayey.

See footnote at end of table.

TABLE 6.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
43----------------- Saipan	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, low strength.	Moderate: droughty, too clayey.
44----------------- Saipan	Moderate: too clayey, slope.	Moderate: shrink-swell, slope.	Severe: slope.	Moderate: shrink-swell, low strength, slope.	Moderate: droughty, slope, too clayey.
45----------------- Saipan	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Slight-----------	Severe: small stones.
46----------------- Saipan	Moderate: too clayey, slope.	Moderate: shrink-swell, slope.	Severe: slope.	Moderate: slope.	Severe: small stones.
47*:					
Saipan-----------	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, low strength.	Moderate: droughty, too clayey.
Rock outcrop.					
48----------------- Shioya	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Moderate: flooding.	Severe: excess salt, droughty.
49*:					
Shioya-----------	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Moderate: flooding.	Severe: excess salt, droughty.
Urban land.					
50*:					
Takpochao--------	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength.	Severe: depth to rock, too clayey.
Rock outcrop.					
51*, 52*:					
Takpochao--------	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock, low strength, slope.	Severe: slope, depth to rock, too clayey.
Rock outcrop.					
53*:					
Takpochao Variant	Severe: depth to rock.	Severe: flooding, depth to rock.	Severe: flooding, depth to rock.	Severe: depth to rock.	Severe: small stones, droughty, depth to rock.
Shioya-----------	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Moderate: flooding.	Severe: excess salt, droughty.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 7.--SANITARY FACILITIES

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "poor," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
1*, 2*:					
Agfayan Variant	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: depth to rock, slope.
Rock outcrop.					
3*, 4*:					
Akina	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Poor: slope, depth to rock.
Badland.					
5 Banaderu	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
6 Banaderu	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
7*:					
Banaderu	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Rock outcrop.					
8*:					
Banaderu	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope, too clayey.	Severe: depth to rock, slope.	Poor: depth to rock, too clayey, hard to pack.
Rock outcrop.					
9 Chacha	Severe: depth to rock, percs slowly.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: depth to rock.
10 Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
11 Chinen	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.

See footnote at end of table.

TABLE 7.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
12------------------- Chinen	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope, too clayey.	Severe: depth to rock, slope.	Poor: depth to rock, too clayey, hard to pack.
13------------------- Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
14------------------- Chinen	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
15*:					
Chinen-------------	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Rock outcrop.					
16*:					
Chinen-------------	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope, too clayey.	Severe: depth to rock, slope.	Poor: depth to rock, too clayey, hard to pack.
Rock outcrop.					
17*:					
Chinen-------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Urban land.					
18*:					
Chinen-------------	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Urban land.					
19*:					
Dandan-------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Chinen-------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.

See footnote at end of table.

TABLE 7.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
20*:					
Dandan	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Chinen	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
21*:					
Dandan	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Chinen	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Pits.					
22*:					
Dandan	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Chinen	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Pits.					
23*:					
Dandan	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Saipan	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey, hard to pack.
24*:					
Dandan	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Saipan	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, hard to pack, slope.

See footnote at end of table.

TABLE 7.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
25----------------- Inarajan	Severe: flooding, wetness, percs slowly.	Severe: flooding.	Severe: flooding, wetness, too clayey.	Severe: flooding, wetness.	Poor: too clayey, hard to pack.
26----------------- Kagman	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight-----------	Poor: too clayey, hard to pack.
27----------------- Kagman	Severe: percs slowly.	Severe: slope.	Severe: too clayey.	Moderate: slope.	Poor: too clayey, hard to pack.
28----------------- Kagman	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight-----------	Poor: too clayey, hard to pack.
29*:					
Kagman-------------	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight-----------	Poor: too clayey, hard to pack.
Urban land.					
30----------------- Laolao	Severe: depth to rock, percs slowly.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
31----------------- Laolao	Severe: depth to rock, percs slowly.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
32, 33------------- Laolao	Severe: depth to rock, percs slowly, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope, too clayey.	Severe: depth to rock, slope.	Poor: depth to rock, too clayey, hard to pack.
34----------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: depth to rock.
35----------------- Luta	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: depth to rock.
36----------------- Luta	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: depth to rock.
37----------------- Luta	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: depth to rock.
38*:					
Luta---------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: depth to rock.
Rock outcrop.					

See footnote at end of table.

TABLE 7.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
39*:					
Luta	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: depth to rock.
Rock outcrop.					
40*:					
Luta	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, seepage, slope.	Severe: depth to rock, slope.	Poor: depth to rock, slope.
Rock outcrop.					
41 Mesei Variant	Severe: flooding, ponding, poor filter.	Severe: seepage, flooding, excess humus.	Severe: flooding, seepage, ponding.	Severe: flooding, seepage, ponding.	Poor: seepage, small stones, ponding.
42*:					
Rock outcrop.					
Takpochao	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope, too clayey.	Severe: depth to rock, slope.	Poor: depth to rock, too clayey, hard to pack.
43 Saipan	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey, hard to pack.
44 Saipan	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, hard to pack, slope.
45 Saipan	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey, hard to pack.
46 Saipan	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, hard to pack, slope.
47*:					
Saipan	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey, hard to pack.
Rock outcrop.					
48 Shioya	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy, excess salt.	Severe: seepage.	Poor: seepage, too sandy, excess salt.

See footnote at end of table.

TABLE 7.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
49*:					
Shioya	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy, excess salt.	Severe: seepage.	Poor: seepage, too sandy, excess salt.
Urban land.					
50*:					
Takpochao	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Rock outcrop.					
51*, 52*:					
Takpochao	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope, too clayey.	Severe: depth to rock, slope.	Poor: depth to rock, too clayey, hard to pack.
Rock outcrop.					
53*:					
Takpochao Variant	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: depth to rock.
Shioya	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy, excess salt.	Severe: seepage.	Poor: seepage, too sandy, excess salt.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--CONSTRUCTION MATERIALS

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
1*:				
Agfayan Variant	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, small stones, slope.
Rock outcrop.				
2*:				
Agfayan Variant	Poor: depth to rock, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, small stones, slope.
Rock outcrop.				
3*:				
Akina	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
Badland.				
4*:				
Akina	Poor: depth to rock, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
Badland.				
5, 6 Banaderu	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey.
7*:				
Banaderu	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey.
Rock outcrop.				
8*:				
Banaderu	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, slope.
Rock outcrop.				
9 Chacha	Poor: depth to rock, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.

See footnote at end of table.

TABLE 8.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
10, 11: Chinen	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock.
12: Chinen	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, slope.
13, 14: Chinen	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, area reclaim, small stones.
15*:				
Chinen	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock.
Rock outcrop.				
16*:				
Chinen	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, slope.
Rock outcrop.				
17*, 18*:				
Chinen	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock.
Urban land.				
19*, 20*:				
Dandan	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Chinen	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock.
21*, 22*:				
Dandan	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Chinen	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock.
Pits.				
23*, 24*:				
Dandan	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.

See footnote at end of table.

TABLE 8.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
23*, 24*:				
Saipan	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
25 Inarajan	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
26, 27, 28 Kagman	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
29*:				
Kagman	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Urban land.				
30, 31 Laolao	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
32 Laolao	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
33 Laolao	Poor: depth to rock, low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
34, 35, 36, 37 Luta	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, large stones.
38*, 39*:				
Luta	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, large stones.
Rock outcrop.				
40*:				
Luta	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, large stones, slope.
Rock outcrop.				
41 Mesei Variant	Poor: wetness.	Probable	Probable	Poor: small stones, area reclaim, excess salt.
42*:				
Rock outcrop.				

See footnote at end of table.

TABLE 8.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
42*:				
Takpochao	Poor: depth to rock, low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, large stones.
43, 44, 45, 46 Saipan	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
47*:				
Saipan	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Rock outcrop.				
48 Shioya	Good	Probable	Improbable: too sandy.	Poor: small stones, excess salt.
49*:				
Shioya	Good	Probable	Improbable: too sandy.	Poor: small stones, excess salt.
Urban land.				
50*, 51*:				
Takpochao	Poor: depth to rock, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, large stones.
Rock outcrop.				
52*:				
Takpochao	Poor: depth to rock, low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, large stones.
Rock outcrop.				
53*:				
Takpochao Variant	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, small stones.
Shioya	Good	Probable	Improbable: too sandy.	Poor: small stones, excess salt.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--WATER MANAGEMENT

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
1*, 2*:						
Agfayan Variant	Severe: depth to rock, slope.	Severe: piping.	Deep to water	Slope, large stones, depth to rock.	Slope, large stones, depth to rock.	Large stones, slope, depth to rock.
Rock outcrop.						
3*, 4*:						
Akina	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, droughty, slow intake.	Slope, depth to rock.	Slope, droughty, depth to rock.
Badland.						
5 Banaderu	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Slope, droughty.	Depth to rock	Droughty, depth to rock.
6 Banaderu	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, droughty.	Slope, depth to rock.	Slope, droughty, depth to rock.
7*, 8*:						
Banaderu	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, droughty.	Slope, depth to rock.	Slope, droughty, depth to rock.
Rock outcrop.						
9 Chacha	Moderate: depth to rock.	Severe: hard to pack.	Deep to water	Droughty, slow intake.	Depth to rock, percs slowly.	Droughty, depth to rock, percs slowly.
10 Chinen	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Slope, droughty.	Depth to rock	Droughty, depth to rock.
11, 12 Chinen	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, droughty.	Slope, depth to rock.	Slope, droughty, depth to rock.
13 Chinen	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Droughty	Depth to rock	Droughty, depth to rock.
14 Chinen	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, droughty.	Slope, depth to rock.	Slope, droughty, depth to rock.
15*, 16*:						
Chinen	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, droughty.	Slope, depth to rock.	Slope, droughty, depth to rock.
Rock outcrop.						

See footnote at end of table.

TABLE 9.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
17*:						
Chinen	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Slope, droughty.	Depth to rock	Droughty, depth to rock.
Urban land.						
18*:						
Chinen	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, droughty.	Slope, depth to rock.	Slope, droughty, depth to rock.
Urban land.						
19*:						
Dandan	Moderate: seepage, depth to rock.	Severe: hard to pack.	Deep to water	Droughty, slow intake.	Depth to rock	Droughty, depth to rock.
Chinen	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Slope, droughty.	Depth to rock	Droughty, depth to rock.
20*:						
Dandan	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, droughty, slow intake.	Slope, depth to rock.	Slope, droughty, depth to rock.
Chinen	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, droughty.	Slope, depth to rock.	Slope, droughty, depth to rock.
21*:						
Dandan	Moderate: seepage, depth to rock.	Severe: hard to pack.	Deep to water	Droughty, slow intake.	Depth to rock	Droughty, depth to rock.
Chinen	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Slope, droughty.	Depth to rock	Droughty, depth to rock.
Pits.						
22*:						
Dandan	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, droughty, slow intake.	Slope, depth to rock.	Slope, droughty, depth to rock.
Chinen	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, droughty.	Slope, depth to rock.	Slope, droughty, depth to rock.
Pits.						
23*:						
Dandan	Moderate: seepage, depth to rock.	Severe: hard to pack.	Deep to water	Droughty, slow intake.	Depth to rock	Droughty, depth to rock.
Saipan	Moderate: seepage.	Severe: hard to pack.	Deep to water	Droughty, slow intake.	Favorable	Droughty.

See footnote at end of table.

TABLE 9.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
24*:						
Dandan	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, droughty, slow intake.	Slope, depth to rock.	Slope, droughty, depth to rock.
Saipan	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, droughty, slow intake.	Slope	Slope, droughty.
25 Inarajan	Slight	Severe: hard to pack, wetness.	Percs slowly, flooding.	Wetness, slow intake.	Wetness, percs slowly.	Percs slowly.
26 Kagman	Slight	Severe: hard to pack.	Deep to water	Slow intake, percs slowly.	Percs slowly	Percs slowly.
27 Kagman	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, slow intake, percs slowly.	Slope, percs slowly.	Slope, percs slowly.
28 Kagman	Slight	Severe: hard to pack.	Deep to water	Droughty	Favorable	Droughty.
29*:						
Kagman	Slight	Severe: hard to pack.	Deep to water	Slow intake, percs slowly.	Percs slowly	Percs slowly.
Urban land.						
30 Laolao	Moderate: depth to rock.	Severe: hard to pack.	Deep to water	Slow intake, depth to rock.	Depth to rock	Depth to rock.
31, 32, 33 Laolao	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, slow intake, depth to rock.	Slope, depth to rock.	Slope, depth to rock.
34 Luta	Severe: depth to rock.	Severe: thin layer.	Deep to water	Large stones, depth to rock.	Large stones, depth to rock.	Large stones, depth to rock.
35 Luta	Severe: depth to rock, slope.	Severe: thin layer.	Deep to water	Slope, large stones, depth to rock.	Slope, large stones, depth to rock.	Large stones, slope, depth to rock.
36 Luta	Severe: depth to rock.	Severe: thin layer.	Deep to water	Large stones, depth to rock.	Large stones, depth to rock.	Large stones, depth to rock.
37 Luta	Severe: depth to rock, slope.	Severe: thin layer.	Deep to water	Slope, large stones, depth to rock.	Slope, large stones, depth to rock.	Large stones, slope, depth to rock.
38*:						
Luta	Severe: depth to rock.	Severe: thin layer.	Deep to water	Large stones, depth to rock.	Large stones, depth to rock.	Large stones, depth to rock.
Rock outcrop.						
39*, 40*:						
Luta	Severe: depth to rock, slope.	Severe: thin layer.	Deep to water	Slope, large stones, depth to rock.	Slope, large stones, depth to rock.	Large stones, slope, depth to rock.

See footnote at end of table.

TABLE 9.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
39*, 40*:						
Rock outcrop.						
41 Mesei Variant	Severe: seepage.	Severe: seepage, ponding, excess salt.	Ponding, flooding, subsides.	Ponding, flooding, excess salt.	Ponding	Wetness, excess salt.
42*:						
Rock outcrop.						
Takpochao	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, large stones, droughty.	Slope, large stones, depth to rock.	Large stones, slope, droughty.
43 Saipan	Moderate: seepage.	Severe: hard to pack.	Deep to water	Droughty, slow intake.	Favorable	Droughty.
44 Saipan	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, droughty, slow intake.	Slope	Slope, droughty.
45 Saipan	Moderate: seepage.	Severe: hard to pack.	Deep to water	Droughty	Favorable	Droughty.
46 Saipan	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, droughty.	Slope	Slope, droughty.
47*:						
Saipan	Moderate: seepage.	Severe: hard to pack.	Deep to water	Droughty, slow intake.	Favorable	Droughty.
Rock outcrop.						
48 Shioya	Severe: seepage.	Severe: seepage, piping, excess salt.	Deep to water	Droughty, fast intake.	Too sandy	Excess salt, droughty.
49*:						
Shioya	Severe: seepage.	Severe: seepage, piping, excess salt.	Deep to water	Droughty, fast intake.	Too sandy	Excess salt, droughty.
Urban land.						
50*, 51*, 52*:						
Takpochao	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, large stones, droughty.	Slope, large stones, depth to rock.	Large stones, slope, droughty.
Rock outcrop.						
53*:						
Takpochao Variant	Severe: depth to rock.	Severe: thin layer.	Deep to water	Slope, droughty, depth to rock.	Large stones, depth to rock.	Large stones, droughty.

See footnote at end of table.

TABLE 9.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
53*:						
Shioya	Severe: seepage.	Severe: seepage, piping, excess salt.	Deep to water	Droughty, fast intake.	Too sandy	Excess salt, droughty.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--ENGINEERING INDEX PROPERTIES

(The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated)

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 8 cm	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	Cm				Pct					Pct	
1*, 2*:											
Agfayan Variant	0-16	Very cobbly clay	ML, CL, SM, SC	A-4, A-6, A-7	25-40	75-85	65-75	55-65	40-60	30-45	5-20
	16-35	Loam, clay loam, cobbly clay loam.	ML, CL, SM, SC	A-4, A-6, A-7	5-20	85-95	75-90	50-80	40-70	30-45	5-20
	35	Weathered bedrock	---	---	---	---	---	---	---	---	---
Rock outcrop.											
3*, 4*:											
Akina----------	0-10	Silty clay-------	MH	A-7	0	95-100	95-100	95-100	85-100	70-80	25-35
	10-61	Clay-------------	MH	A-7	0	95-100	95-100	90-100	75-100	75-85	25-35
	61	Weathered bedrock	---	---	---	---	---	---	---	---	---
Badland.											
5, 6------------ Banaderu	0-18	Clay loam--------	MH, ML	A-7	5-15	90-95	85-95	75-95	50-80	40-60	10-20
	18-48	Clay-------------	MH	A-7	5-10	95-100	95-100	85-100	70-95	50-70	20-30
	48	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
7*, 8*:											
Banaderu-------	0-18	Clay loam--------	MH, ML	A-7	5-15	90-95	85-95	75-95	50-80	40-60	10-20
	18-48	Clay-------------	MH	A-7	5-10	95-100	95-100	85-100	70-95	50-70	20-30
	48	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
9--------------- Chacha	0-18	Clay-------------	MH, CH	A-7	0	95-100	90-100	70-100	65-95	60-80	25-60
	18-94	Clay-------------	MH, CH	A-7	0	100	100	80-95	75-90	80-100	40-60
	94-152	Weathered bedrock	---	---	---	---	---	---	---	---	---
10, 11, 12------ Chinen	0-18	Clay loam--------	ML, MH	A-7	0-10	90-100	85-95	75-90	70-90	45-65	15-30
	18-35	Clay, clay loam, silty clay.	ML, MH	A-7	0-5	90-100	90-95	80-95	55-90	40-60	10-20
	35	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
13, 14---------- Chinen	0-20	Very gravelly sandy loam.	GM, GP-GM, GM-GC	A-1	5-10	40-55	25-45	15-35	5-25	15-25	NP-5
	20-38	Clay, clay loam	ML, MH	A-7	0-10	90-100	85-95	75-90	60-80	45-65	15-30
	38-53	Clay, clay loam, silty clay.	ML, MH	A-7	0-5	90-100	90-95	80-95	65-90	40-60	10-20
	53	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
15*, 16*:											
Chinen---------	0-18	Clay loam--------	ML, MH	A-7	0-10	90-100	85-95	75-90	70-90	45-65	15-30
	18-35	Clay, clay loam, silty clay.	ML, MH	A-7	0-5	90-100	90-95	80-95	55-90	40-60	10-20
	35	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											

See footnote at end of table.

TABLE 10.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 8 cm	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	Cm				Pct					Pct	
17*, 18*:											
Chinen---------	0-18	Clay loam--------	ML, MH	A-7	0-10	90-100	85-95	75-90	70-90	45-65	15-30
	18-35	Clay, clay loam, silty clay.	ML, MH	A-7	0-5	90-100	90-95	80-95	55-90	40-60	10-20
	35	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Urban land.											
19*, 20*:											
Dandan---------	0-12	Clay-------------	ML, MH	A-7	0-5	90-100	85-100	75-95	70-95	45-65	15-30
	12-66	Clay-------------	ML, MH	A-7	0	100	100	90-95	70-95	40-60	10-20
	66	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Chinen---------	0-18	Clay loam--------	ML, MH	A-7	0-10	90-100	85-95	75-90	70-90	45-65	15-30
	18-35	Clay, clay loam, silty clay.	ML, MH	A-7	0-5	90-100	90-95	80-95	55-90	40-60	10-20
	35	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
21*, 22*:											
Dandan---------	0-12	Clay-------------	ML, MH	A-7	0-5	90-100	85-100	75-95	70-95	45-65	15-30
	12-66	Clay-------------	ML, MH	A-7	0	100	100	90-95	70-95	40-60	10-20
	66	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Chinen---------	0-18	Clay loam--------	ML, MH	A-7	0-10	90-100	85-95	75-90	70-90	45-65	15-30
	18-35	Clay, clay loam, silty clay.	ML, MH	A-7	0-5	90-100	90-95	80-95	55-90	40-60	10-20
	35	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Pits.											
23*, 24*:											
Dandan---------	0-12	Clay-------------	ML, MH	A-7	0-5	90-100	85-100	75-95	70-95	45-65	15-30
	12-66	Clay-------------	ML, MH	A-7	0	100	100	90-95	70-95	40-60	10-20
	66	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Saipan---------	0-16	Clay-------------	ML, MH	A-7	0	90-100	85-100	80-100	70-95	45-65	15-30
	16-152	Silty clay, clay	ML, MH	A-7	0	100	100	90-100	80-95	40-70	10-30
25-------------- Inarajan	0-25	Clay-------------	MH	A-7	0	100	100	90-100	70-95	70-90	30-50
	25-46	Clay, silty clay	MH	A-7	0	100	100	90-100	70-95	70-90	30-50
	46-152	Silty clay, clay	MH	A-7	0	100	95-100	85-100	70-95	60-80	20-40
26, 27---------- Kagman	0-15	Clay-------------	MH	A-7	0-5	90-100	85-100	80-100	75-100	60-80	20-30
	15-152	Clay-------------	MH	A-7	0	100	100	95-100	90-100	80-100	30-50
28-------------- Kagman	0-20	Very gravelly sandy loam.	GM, GP-GM, GP-GC	A-1	0-10	40-55	25-45	15-35	10-25	20-30	NP-5
	20-35	Clay, clay loam, silty clay.	MH	A-7	0-5	90-100	85-100	70-100	60-95	60-80	20-30
	35-152	Clay-------------	MH	A-7	0	100	100	85-100	70-95	80-100	40-50
29*:											
Kagman---------	0-15	Clay-------------	MH	A-7	0-5	90-100	85-100	80-100	75-100	60-80	20-30
	15-152	Clay-------------	MH	A-7	0	100	100	95-100	90-100	80-100	30-50

See footnote at end of table.

TABLE 10.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 8 cm	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	Cm				Pct					Pct	
29*:											
Urban land.											
30, 31, 32, 33--	0-15	Clay-------------	MH	A-7	0	95-100	95-100	95-100	75-100	70-80	25-35
Laolao	15-82	Clay-------------	MH	A-7	0	100	100	95-100	75-100	75-85	25-35
	82	Weathered bedrock	---	---	---	---	---	---	---	---	---
34, 35, 36, 37--	0-7	Cobbly clay loam	ML	A-5	15-30	90-95	80-90	65-80	50-70	40-45	5-10
Luta	7-15	Cobbly clay loam, cobbly loam.	ML, SM	A-5, A-4	15-30	90-95	80-90	65-80	45-70	35-45	5-10
	15-30	Weathered bedrock	---	---	---	---	---	---	---	---	---
	30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
38*, 39*, 40*:											
Luta-----------	0-7	Cobbly clay loam	ML	A-5	15-30	90-95	80-90	65-80	50-70	40-45	5-10
	7-15	Cobbly clay loam, cobbly loam.	ML, SM	A-5, A-4	15-30	90-95	80-90	65-80	45-70	35-45	5-10
	15-30	Weathered bedrock	---	---	---	---	---	---	---	---	---
	30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
41--------------	0-20	Muck-------------	PT	A-8	0	90-100	85-100	80-100	80-100	---	---
Mesei Variant	20-60	Gravelly muck----	PT, GP-GM, GM-GC, GM	A-8, A-1-a, A-1-b	5-10	40-55	25-45	15-35	5-25	---	NP-5
	60-152	Gravelly sandy loam.	GP-GM, SM, SP-SM, GM	A-1-a, A-1-b	5-10	30-60	15-50	10-30	5-20	---	NP
42*:											
Rock outcrop.											
Takpochao------	0-18	Very cobbly clay	ML, MH	A-7	15-30	75-90	70-90	55-80	50-75	45-65	15-30
	18-30	Very cobbly clay, very cobbly clay loam.	ML, MH	A-7	15-30	75-90	70-90	55-80	50-75	45-65	15-30
	30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
43, 44----------	0-16	Clay-------------	ML, MH	A-7	0	90-100	85-100	80-100	70-95	45-65	15-30
Saipan	16-152	Silty clay, clay	ML, MH	A-7	0	100	100	90-100	80-95	40-70	10-30
45, 46----------	0-20	Very gravelly sandy loam.	GM, GP-GM	A-1	5-10	40-55	25-45	20-35	10-25	20-35	NP-5
Saipan	20-35	Clay, silty clay	ML, MH	A-7	0	90-100	85-100	75-100	60-95	45-65	15-30
	35-152	Clay, silty clay	ML, MH	A-7	0	100	100	90-100	70-95	45-65	15-30
47*:											
Saipan---------	0-16	Clay-------------	ML, MH	A-7	0	90-100	85-100	80-100	70-95	45-65	15-30
	16-152	Silty clay, clay	ML, MH	A-7	0	100	100	90-100	80-95	40-70	10-30
Rock outcrop.											
48--------------	0-25	Loamy sand-------	SM	A-2	0-5	90-100	85-95	50-65	15-25	---	NP
Shioya	25-152	Sand-------------	SP-SM, SP	A-3, A-2	0-10	85-95	80-95	50-60	0-10	---	NP

See footnote at end of table.

TABLE 10.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 8 cm	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	Cm				Pct					Pct	
49*:											
Shioya---------	0-25	Loamy sand-------	SM	A-2	0-5	90-100	85-95	50-65	15-25	---	NP
	25-152	Sand-------------	SP-SM, SP	A-3, A-2	0-10	85-95	80-95	50-60	0-10	---	NP
Urban land.											
50*, 51*, 52*:											
Takpochao------	0-18	Very cobbly clay	ML, MH	A-7	15-30	75-90	70-90	55-80	50-75	45-65	15-30
	18-30	Very cobbly clay, very cobbly clay loam.	ML, MH	A-7	15-30	75-90	70-90	55-80	50-75	45-65	15-30
	30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
53*:											
Takpochao Variant-------	0-15	Very gravelly sandy loam.	SM	A-1	10-20	70-80	40-55	30-40	15-25	15-30	NP-5
	15	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Shioya---------	0-25	Loamy sand-------	SM	A-2	0-5	90-100	85-95	50-65	15-25	---	NP
	25-152	Sand-------------	SP-SM, SP	A-3, A-2	0-10	85-95	80-95	50-60	0-10	---	NP

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

(The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated)

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Organic matter
	Cm	Pct	g/cc	Cm/hr	Cm/cm	pH	mmhos/cm				Pct
1*, 2*:											
Agfayan Variant	0-16	30-35	0.90-1.00	1.5-5.0	0.09-0.10	5.6-7.3	<2	Low---------	0.20	2	4-8
	16-35	20-35	0.90-1.00	1.5-5.0	0.10-0.12	6.1-7.3	<2	Low---------	0.20		
	35	---	---	---	---	---	---	------------	----		
Rock outcrop.											
3*, 4*:											
Akina----------	0-10	45-60	0.85-1.00	0.5-1.5	0.17-0.20	5.1-7.3	<2	Moderate----	0.20	3	6-10
	10-61	60-80	1.00-1.20	0.5-1.5	0.08-0.10	4.5-6.0	<2	Moderate----	0.15		
	61	---	---	---	---	---	---	------------	----		
Badland.											
5, 6------------ Banaderu	0-18	30-40	1.00-1.20	1.5-5.0	0.15-0.17	6.6-7.8	<2	Moderate----	0.20	1	4-8
	18-48	40-60	1.20-1.40	1.5-5.0	0.10-0.13	6.6-7.8	<2	Moderate----	0.15		
	48	---	---	---	---	---	---	------------	----		
7*, 8*:											
Banaderu-------	0-18	30-40	1.00-1.20	1.5-5.0	0.15-0.17	6.6-7.8	<2	Moderate----	0.20	1	4-8
	18-48	40-60	1.20-1.40	1.5-5.0	0.10-0.13	6.6-7.8	<2	Moderate----	0.15		
	48	---	---	---	---	---	---	------------	----		
Rock outcrop.											
9--------------- Chacha	0-18	50-80	1.00-1.20	0.5-1.5	0.10-0.15	5.6-7.8	<2	High--------	0.15	3	4-8
	18-94	60-90	1.00-1.20	0.2-0.5	0.10-0.15	5.1-6.5	<2	High--------	0.15		
	94-152	---	---	---	---	---	---	------------	----		
10, 11, 12------ Chinen	0-18	40-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15	1	4-7
	18-35	35-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15		
	35	---	---	---	---	---	---	------------	----		
13, 14---------- Chinen	0-20	5-20	1.80-2.00	1.5-5.0	0.01-0.03	7.4-8.4	2-4	Low---------	0.10	1	.5-2
	20-38	35-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15		
	38-53	35-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15		
	53	---	---	---	---	---	---	------------	----		
15*, 16*:											
Chinen---------	0-18	40-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15	1	4-7
	18-35	35-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15		
	35	---	---	---	---	---	---	------------	----		
Rock outcrop.											
17*, 18*:											
Chinen---------	0-18	40-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15	1	4-7
	18-35	35-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15		
	35	---	---	---	---	---	---	------------	----		
Urban land.											
19*, 20*:											
Dandan---------	0-12	35-50	1.00-1.20	1.5-5.0	0.10-0.15	5.6-7.3	<2	Moderate----	0.15	2	4-7
	12-66	40-60	1.00-1.20	1.5-5.0	0.10-0.15	6.1-7.3	<2	Moderate----	0.15		
	66	---	---	---	---	---	---	------------	----		

See footnote at end of table.

TABLE 11.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Organic matter
	Cm	Pct	g/cc	Cm/hr	Cm/cm	pH	mmhos/cm				Pct
19*, 20*:											
Chinen---------	0-18	40-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15	1	4-7
	18-35	35-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15		
	35	---	---	---	---	---	---	------------	----		
21*, 22*:											
Dandan---------	0-12	35-50	1.00-1.20	1.5-5.0	0.10-0.15	5.6-7.3	<2	Moderate----	0.15	2	4-7
	12-66	40-60	1.00-1.20	1.5-5.0	0.10-0.15	6.1-7.3	<2	Moderate----	0.15		
	66	---	---	---	---	---	---	------------	----		
Chinen---------	0-18	40-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15	1	4-7
	18-35	35-60	1.00-1.20	1.5-5.0	0.10-0.15	6.6-7.8	<2	Moderate----	0.15		
	35	---	---	---	---	---	---	------------	----		
Pits.											
23*, 24*:											
Dandan---------	0-12	35-50	1.00-1.20	1.5-5.0	0.10-0.15	5.6-7.3	<2	Moderate----	0.15	2	4-7
	12-66	40-60	1.00-1.20	1.5-5.0	0.10-0.15	6.1-7.3	<2	Moderate----	0.15		
	66	---	---	---	---	---	---	------------	----		
Saipan---------	0-16	40-60	1.00-1.20	1.5-5.0	0.10-0.13	6.1-7.8	<2	Moderate----	0.15	5	4-7
	16-152	40-60	1.20-1.40	1.5-5.0	0.10-0.13	6.1-7.8	<2	Moderate----	0.15		
25-------------- Inarajan	0-25	45-80	0.90-1.10	0.2-0.5	0.18-0.20	5.1-7.3	<2	High--------	0.24	5	5-7
	25-46	60-80	0.90-1.10	0.2-0.5	0.13-0.15	6.1-8.4	<2	High--------	0.28		
	46-152	60-80	0.90-1.10	0.2-0.5	0.11-0.13	6.1-8.4	<2	Moderate----	0.17		
26, 27---------- Kagman	0-15	40-70	0.90-1.20	0.5-1.5	0.12-0.18	6.1-7.8	<2	Moderate----	0.15	5	4-8
	15-152	60-90	1.00-1.20	0.5-1.5	0.10-0.15	5.1-7.8	<2	Moderate----	0.15		
28-------------- Kagman	0-20	5-15	1.10-1.20	1.5-5.0	0.04-0.06	7.4-8.4	2-4	Low---------	0.15	5	.5-2
	20-35	35-70	0.90-1.20	0.5-1.5	0.12-0.18	6.6-7.3	<2	Moderate----	0.15		
	35-152	60-90	1.00-1.20	0.5-1.5	0.10-0.15	5.1-7.3	<2	Moderate----	0.15		
29*:											
Kagman---------	0-15	40-70	0.90-1.20	0.5-1.5	0.12-0.18	6.1-7.8	<2	Moderate----	0.15	5	4-8
	15-152	60-90	1.00-1.20	0.5-1.5	0.10-0.15	5.1-7.8	<2	Moderate----	0.15		
Urban land.											
30, 31, 32, 33-- Laolao	0-15	50-70	0.85-1.10	1.5-5.0	0.17-0.20	5.1-7.3	<2	Moderate----	0.15	3	4-9
	15-82	60-80	1.00-1.20	1.5-5.0	0.11-0.14	5.6-7.3	<2	Moderate----	0.15		
	82	---	---	---	---	---	---	------------	----		
34, 35, 36, 37-- Luta	0-7	20-35	0.70-1.00	5.0-15	0.14-0.18	6.6-7.8	<2	Low---------	0.10	1	4-8
	7-15	20-35	0.70-1.00	5.0-15	0.14-0.18	6.6-7.3	<2	Low---------	0.10		
	15-30	---	---	---	---	---	---	------------	----		
	30	---	---	---	---	---	---	------------	----		
38*, 39*, 40*:											
Luta-----------	0-7	20-35	0.70-1.00	5.0-15	0.14-0.18	6.6-7.8	<2	Low---------	0.10	1	4-8
	7-15	20-35	0.70-1.00	5.0-15	0.14-0.18	6.6-7.3	<2	Low---------	0.10		
	15-30	---	---	---	---	---	---	------------	----		
	30	---	---	---	---	---	---	------------	----		
Rock outcrop.											
41-------------- Mesei Variant	0-20	10-20	0.35-0.60	1.5-5.0	0.25-0.30	6.6-7.8	2-8	Low---------	0.05	1	8-10
	20-60	15-30	0.50-0.80	1.5-5.0	0.20-0.25	7.4-8.4	8-16	Low---------	0.05		
	60-152	0-10	1.20-1.30	15-50	0.04-0.08	7.9-8.4	>16	Low---------	0.05		

See footnote at end of table.

TABLE 11.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Organic matter
	Cm	Pct	g/cc	Cm/hr	Cm/cm	pH	mmhos/cm				Pct
42*:											
Rock outcrop---	---	---	---	---	---	---	<2	------------	----	---	---
Takpochao------	0-18	40-60	1.00-1.20	1.5-5.0	0.08-0.13	6.6-7.3	<2	Moderate----	0.10	1	4-8
	18-30	35-70	1.00-1.20	1.5-5.0	0.08-0.13	6.6-7.8	<2	Moderate----	0.10		
	30	---	---	---	---	---	---	------------	----		
43, 44---------- Saipan	0-16	40-60	1.00-1.20	1.5-5.0	0.10-0.13	6.1-7.8	<2	Moderate----	0.15	5	4-7
	16-152	40-60	1.20-1.40	1.5-5.0	0.10-0.13	6.1-7.8	<2	Moderate----	0.15		
45, 46---------- Saipan	0-20	5-15	1.30-1.40	5-15	0.04-0.06	7.4-8.4	2-4	Low---------	0.10	5	1-3
	20-35	40-60	1.00-1.20	1.5-5.0	0.10-0.15	6.1-7.8	<2	Moderate----	0.15		
	35-152	40-60	1.20-1.40	1.5-5.0	0.10-0.13	6.1-7.8	<2	Moderate----	0.15		
47*:											
Saipan---------	0-16	40-60	1.00-1.20	1.5-5.0	0.10-0.13	6.1-7.8	<2	Moderate----	0.15	5	4-7
	16-152	40-60	1.20-1.40	1.5-5.0	0.10-0.13	6.1-7.8	<2	Moderate----	0.15		
Rock outcrop.											
48-------------- Shioya	0-25	0-3	1.10-1.25	15-50	0.08-0.10	7.4-8.4	8-16	Low---------	0.15	5	4-5
	25-152	0-5	1.20-1.30	15-50	0.05-0.08	7.4-9.0	>16	Low---------	0.10		
49*:											
Shioya---------	0-25	0-3	1.10-1.25	15-50	0.08-0.10	7.4-8.4	8-16	Low---------	0.15	5	4-5
	25-152	0-5	1.20-1.30	15-50	0.05-0.08	7.4-9.0	>16	Low---------	0.10		
Urban land.											
50*, 51*, 52*:											
Takpochao------	0-18	40-60	1.00-1.20	1.5-5.0	0.08-0.13	6.6-7.3	<2	Moderate----	0.10	1	4-8
	18-30	35-70	1.00-1.20	1.5-5.0	0.08-0.13	6.6-7.8	<2	Moderate----	0.10		
	30	---	---	---	---	---	---	------------	----		
Rock outcrop.											
53*:											
Takpochao Variant-------	0-15	5-20	1.00-1.20	15-50	0.04-0.07	7.4-8.4	2-4	Low---------	0.05	1	6-10
	15	---	---	---	---	---	---	------------	----		
Shioya---------	0-25	0-3	1.10-1.25	15-50	0.08-0.10	7.4-8.4	8-16	Low---------	0.15	5	4-5
	25-152	0-5	1.20-1.30	15-50	0.05-0.08	7.4-9.0	>16	Low---------	0.10		

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--SOIL AND WATER FEATURES

("Flooding" and "water table" and terms such as "rare," "brief," and "apparent" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated)

Soil name and map symbol	Hydrologic group	Flooding			High water table			Bedrock		Subsidence		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness	Initial	Total	Uncoated steel	Concrete
					M			Cm		Cm	Cm		
1*, 2*:													
Agfayan Variant-	D	None--------	---	---	>1.8	---	---	25-51	Soft	---	---	Moderate	Moderate.
Rock outcrop.													
3*, 4*:													
Akina-----------	B	None--------	---	---	>1.8	---	---	>152	Soft	---	---	Moderate	Moderate.
Badland.													
5, 6------------ Banaderu	D	None--------	---	---	>1.8	---	---	25-51	Hard	---	---	Moderate	Low.
7*, 8*:													
Banaderu--------	D	None--------	---	---	>1.8	---	---	25-51	Hard	---	---	Moderate	Low.
Rock outcrop.													
9--------------- Chacha	C	None--------	---	---	>1.8	---	---	102-152	Soft	---	---	Moderate	Moderate.
10, 11, 12------- Chinen	D	None--------	---	---	>1.8	---	---	25-51	Hard	---	---	Moderate	Low.
13, 14----------- Chinen	D	None--------	---	---	>1.8	---	---	51-71	Hard	---	---	Moderate	Low.
15*, 16*:													
Chinen----------	D	None--------	---	---	>1.8	---	---	25-51	Hard	---	---	Moderate	Low.
Rock outcrop.													
17*, 18*:													
Chinen----------	D	None--------	---	---	>1.8	---	---	25-51	Hard	---	---	Moderate	Low.
Urban land.													
19*, 20*:													
Dandan----------	C	None--------	---	---	>1.8	---	---	51-102	Hard	---	---	Moderate	Moderate.
Chinen----------	D	None--------	---	---	>1.8	---	---	25-51	Hard	---	---	Moderate	Low.
21*, 22*:													
Dandan----------	C	None--------	---	---	>1.8	---	---	51-102	Hard	---	---	Moderate	Moderate.

See footnote at end of table.

TABLE 12.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hard-ness	Subsidence: Ini-tial	Subsidence: Total	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					M			Cm		Cm	Cm		
21*, 22*:													
Chinen----------	D	None--------	---	---	>1.8	---	---	25-51	Hard	---	---	Moderate	Low.
Pits.													
23*, 24*:													
Dandan----------	C	None--------	---	---	>1.8	---	---	51-102	Hard	---	---	Moderate	Moderate.
Saipan----------	B	None--------	---	---	>1.8	---	---	>152	---	---	---	Moderate	Low.
25--------------- Inarajan	C	Occasional	Brief-----	Jun-Nov	0.5-1.0	Apparent	Jun-Dec	>152	---	---	---	Moderate	Moderate.
26, 27, 28------- Kagman	C	None--------	---	---	>1.8	---	---	>152	---	---	---	Moderate	Moderate.
29*:													
Kagman----------	C	None--------	---	---	>1.8	---	---	>152	---	---	---	Moderate	Moderate.
Urban land.													
30, 31, 32, 33--- Laolao	B	None--------	---	---	>1.8	---	---	51-102	Soft	---	---	Moderate	High.
34, 35, 36, 37--- Luta	D	None--------	---	---	>1.8	---	---	10-25	Hard	---	---	Low------	Low.
38*, 39*, 40*:													
Luta------------	D	None--------	---	---	>1.8	---	---	10-25	Hard	---	---	Low------	Low.
Rock outcrop.													
41--------------- Mesei Variant	D	Frequent----	Very brief	Jul-Nov	+.9-0.3	Apparent	Jan-Dec	>152	---	10-25	40-51	High-----	High.
42*:													
Rock outcrop.													
Takpochao-------	D	None--------	---	---	>1.8	---	---	10-40	Hard	---	---	Low------	Low.
43, 44, 45, 46--- Saipan	B	None--------	---	---	>1.8	---	---	>152	---	---	---	Moderate	Low.
47*:													
Saipan----------	B	None--------	---	---	>1.8	---	---	>152	---	---	---	Moderate	Low.
Rock outcrop.													

See footnote at end of table.

TABLE 12.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Subsidence		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard-ness	Ini-tial	Total	Uncoated steel	Concrete
					M			Cm		Cm	Cm		
48--------------- Shioya	A	Rare---------	---	---	>1.8	---	---	>152	---	---	---	High-----	High.
49*:													
Shioya----------	A	Rare---------	---	---	>1.8	---	---	>152	---	---	---	High-----	High.
Urban land.													
50*, 51*, 52*:													
Takpochao-------	D	None---------	---	---	>1.8	---	---	10-40	Hard	---	---	Low------	Low.
Rock outcrop.													
53*:													
Takpochao Variant	B	Rare---------	---	---	>1.8	---	---	10-25	Hard	---	---	Moderate	Moderate.
Shioya----------	A	Rare---------	---	---	>1.8	---	---	>152	---	---	---	High-----	High.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Agfayan Variant	Loamy, mixed, isohyperthermic, shallow Udorthentic Haplustolls
Akina	Clayey, kaolinitic, isohyperthermic Oxic Haplustults
Banaderu	Clayey, gibbsitic, isohyperthermic Lithic Argiustolls
Chacha	Very fine, kaolinitic, isohyperthermic Oxic Haplustalfs
Chinen	Clayey, oxidic, isohyperthermic Lithic Argiustolls
Dandan	Fine, oxidic, isohyperthermic Oxic Haplustalfs
Inarajan	Very fine, mixed, nonacid, isohyperthermic Aeric Tropic Fluvaquents
Kagman	Very fine, kaolinitic, isohyperthermic Oxic Paleustalfs
Laolao	Very fine, oxidic, isohyperthermic Udic Haplustalfs
Luta	Loamy, oxidic, nonacid, isohyperthermic Lithic Ustorthents
Mesei Variant	Loamy-skeletal, carbonatic, euic, isohyperthermic Terric Troposaprists
Saipan	Fine, mixed, isohyperthermic Oxic Haplustalfs
Shioya	Carbonatic, isohyperthermic Typic Ustipsamments
Takpochao	Clayey-skeletal, kaolinitic, isohyperthermic Lithic Haplustolls
Takpochao Variant	Loamy-skeletal, carbonatic, isohyperthermic Lithic Haplustolls

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SOIL LEGEND

(NOT ALL SOIL UNITS SHOWN IN THIS LEGEND OCCUR ON ALL ISLANDS)

SOILS ON LOWLANDS

1	MESEI VARIANT: Moderately deep, very poorly drained, level soils; in depressional areas
2	SHIOYA: Very deep, excessively drained, level to nearly level soils; on coastal strands
3	TAKPOCHAO VARIANT-SHIOYA: Very shallow and very deep, excessively drained, level to gently sloping soils; on coastal strands and coastal plateaus

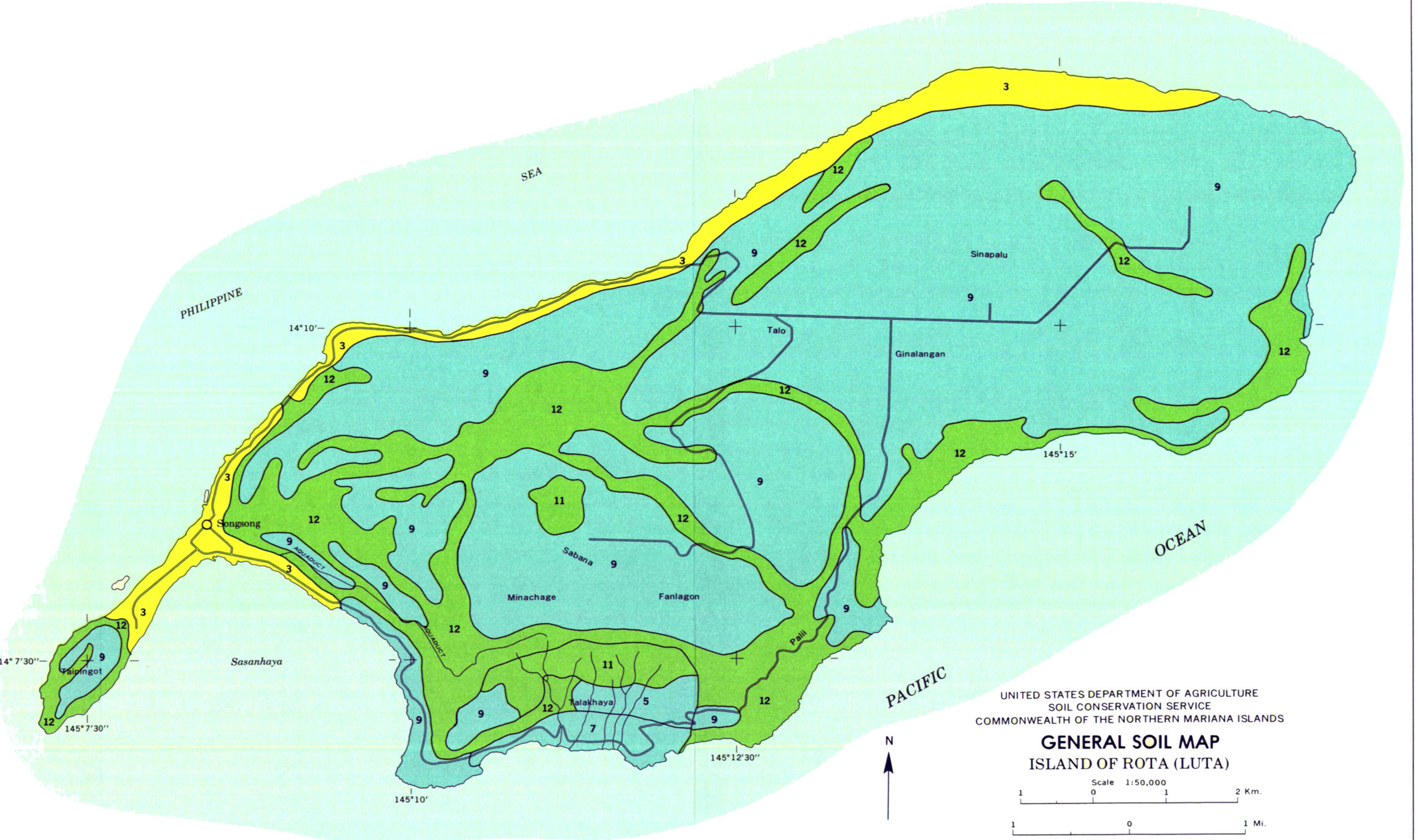
SOILS ON LIMESTONE PLATEAUS

4	BANADERU-ROCK OUTCROP: Shallow, well drained, nearly level to moderately steep soils, and Rock outcrop; on limestone plateaus
5	CHINEN-TAKPOCHAO: Very shallow and shallow, well drained, nearly level to strongly sloping soils; on limestone plateaus and side slopes
6	CHINEN-URBAN LAND: Shallow, well drained, nearly level soils, and Urban land; on limestone plateaus
7	DANDAN-CHINEN: Shallow and moderately deep, well drained, nearly level to strongly sloping soils; on limestone plateaus
8	KAGMAN-SAIPAN: Deep and very deep, well drained, nearly level to strongly sloping soils; on limestone plateaus
9	LUTA: Very shallow, well drained, nearly level to strongly sloping soils; on limestone plateaus
10	SAIPAN-DANDAN: Moderately deep and very deep, well drained, nearly level to gently sloping soils; on limestone plateaus

SOILS ON UPLANDS

11	LAOLAO-AKINA: Moderately deep, well drained, strongly sloping to steep soils; on volcanic uplands
12	ROCK OUTCROP-TAKPOCHAO-LUTA: Shallow and very shallow, well drained, strongly sloping to extremely steep soils, and Rock outcrop; on limestone escarpments
13	TAKPOCHAO-CHINEN-ROCK OUTCROP: Shallow, well drained, strongly sloping to extremely steep soils, and Rock outcrop; on limestone escarpments and plateaus

Compiled 1988



UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

GENERAL SOIL MAP
ISLAND OF ROTA (LUTA)

Scale 1:50,000

1 0 1 2 Km.

1 0 1 Mi.

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

SOIL LEGEND

(NOT ALL SOIL UNITS SHOWN IN THIS LEGEND OCCUR ON ALL ISLANDS)

SOILS ON LOWLANDS

1 MESEI VARIANT: Moderately deep, very poorly drained, level soils; in depressional areas

2 SHIOYA: Very deep, excessively drained, level to nearly level soils; on coastal strands

3 TAKPOCHAO VARIANT-SHIOYA: Very shallow and very deep, excessively drained, level to gently sloping soils; on coastal strands and coastal plateaus

SOILS ON LIMESTONE PLATEAUS

4 BANADERU-ROCK OUTCROP: Shallow, well drained, nearly level to moderately steep soils, and Rock outcrop; on limestone plateaus

5 CHINEN-TAKPOCHAO: Very shallow and shallow, well drained, nearly level to strongly sloping soils; on limestone plateaus and side slopes

6 CHINEN-URBAN LAND: Shallow, well drained, nearly level soils, and Urban land; on limestone plateaus

7 DANDAN-CHINEN: Shallow and moderately deep, well drained, nearly level to strongly sloping soils; on limestone plateaus

8 KAGMAN-SAIPAN: Deep and very deep, well drained, nearly level to strongly sloping soils; on limestone plateaus

9 LUTA: Very shallow, well drained, nearly level to strongly sloping soils; on limestone plateaus

10 SAIPAN-DANDAN: Moderately deep and very deep, well drained, nearly level to gently sloping soils; on limestone plateaus

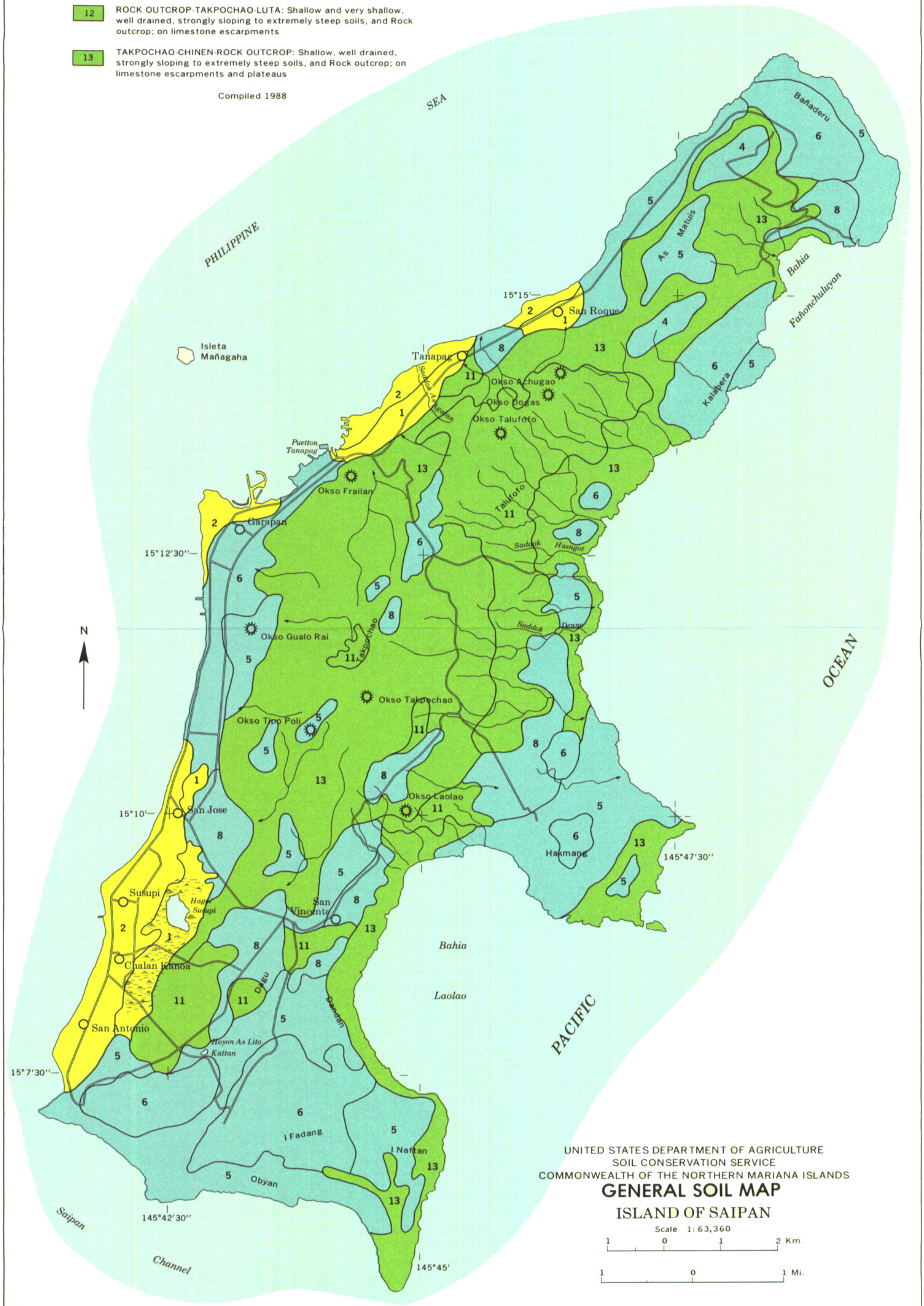
SOILS ON UPLANDS

11 LAOLAO-AKINA: Moderately deep, well drained, strongly sloping to steep soils; on volcanic uplands

12 ROCK OUTCROP-TAKPOCHAO-LUTA: Shallow and very shallow, well drained, strongly sloping to extremely steep soils, and Rock outcrop; on limestone escarpments

13 TAKPOCHAO-CHINEN-ROCK OUTCROP: Shallow, well drained, strongly sloping to extremely steep soils, and Rock outcrop; on limestone escarpments and plateaus

Compiled 1988



UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

GENERAL SOIL MAP

ISLAND OF SAIPAN

Scale 1:63,360

1 0 1 2 Km.

1 0 1 Mi.

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

SOIL LEGEND

(NOT ALL SOIL UNITS SHOWN IN THIS LEGEND OCCUR ON ALL ISLANDS)

SOILS ON LOWLANDS

1	MESEI VARIANT: Moderately deep, very poorly drained, level soils; in depressional areas
2	SHIOYA: Very deep, excessively drained, level to nearly level soils; on coastal strands
3	TAKPOCHAO VARIANT-SHIOYA: Very shallow and very deep, excessively drained, level to gently sloping soils; on coastal strands and coastal plateaus

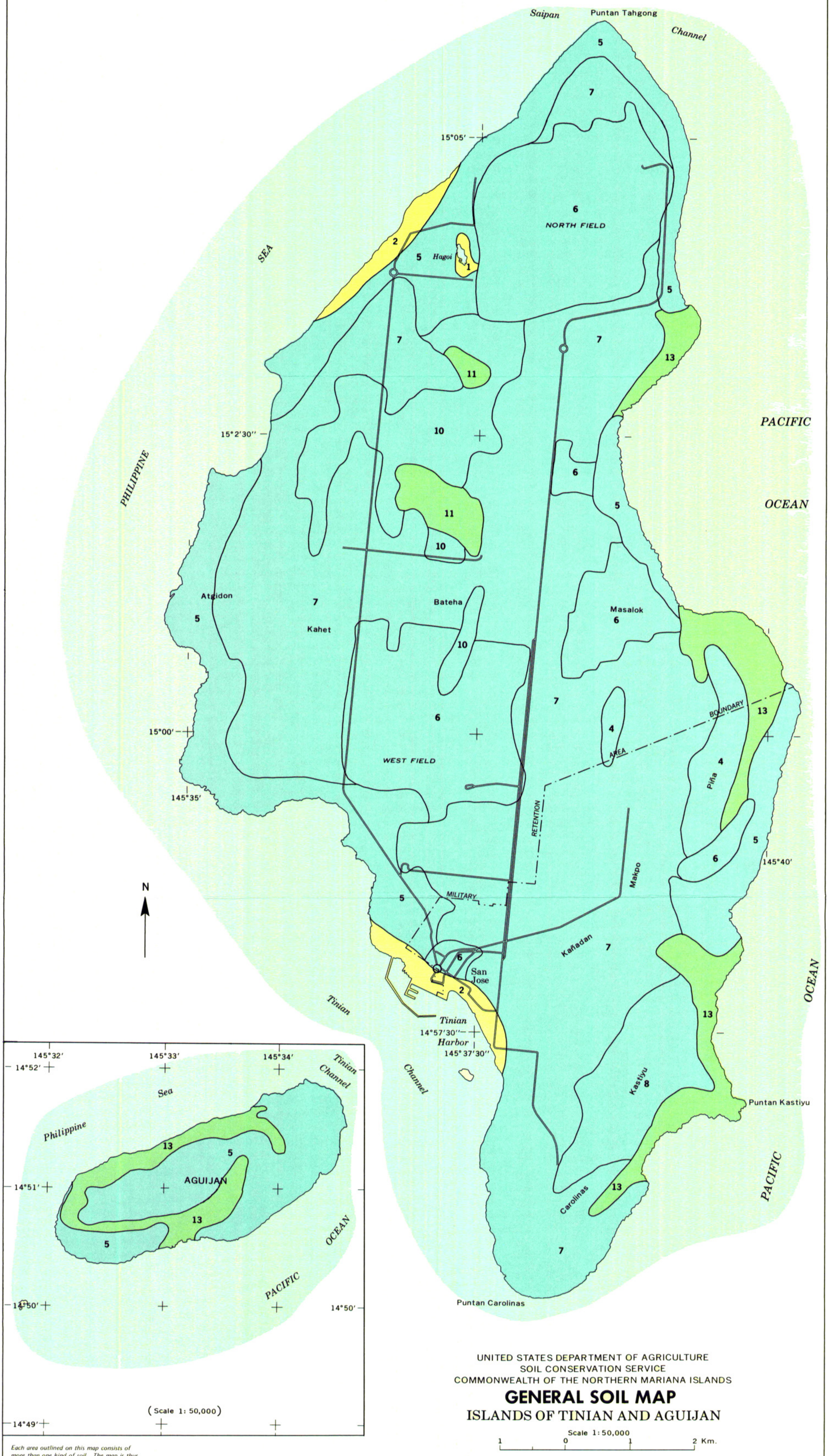
SOILS ON LIMESTONE PLATEAUS

4	BANADERU-ROCK OUTCROP: Shallow, well drained, nearly level to moderately steep soils, and Rock outcrop; on limestone plateaus
5	CHINEN-TAKPOCHAO: Very shallow and shallow, well drained, nearly level to strongly sloping soils; on limestone plateaus and side slopes
6	CHINEN-URBAN LAND: Shallow, well drained, nearly level soils, and Urban land; on limestone plateaus
7	DANDAN-CHINEN: Shallow and moderately deep, well drained, nearly level to strongly sloping soils; on limestone plateaus
8	KAGMAN-SAIPAN: Deep and very deep, well drained, nearly level to strongly sloping soils; on limestone plateaus
9	LUTA: Very shallow, well drained, nearly level to strongly sloping soils; on limestone plateaus
10	SAIPAN-DANDAN: Moderately deep and very deep, well drained, nearly level to gently sloping soils; on limestone plateaus

SOILS ON UPLANDS

11	LAOLAO-AKINA: Moderately deep, well drained, strongly sloping to steep soils; on volcanic uplands
12	ROCK OUTCROP-TAKPOCHAO-LUTA: Shallow and very shallow, well drained, strongly sloping to extremely steep soils, and Rock outcrop; on limestone escarpments
13	TAKPOCHAO-CHINEN-ROCK OUTCROP: Shallow, well drained, strongly sloping to extremely steep soils, and Rock outcrop; on limestone escarpments and plateaus

Compiled 1988



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UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

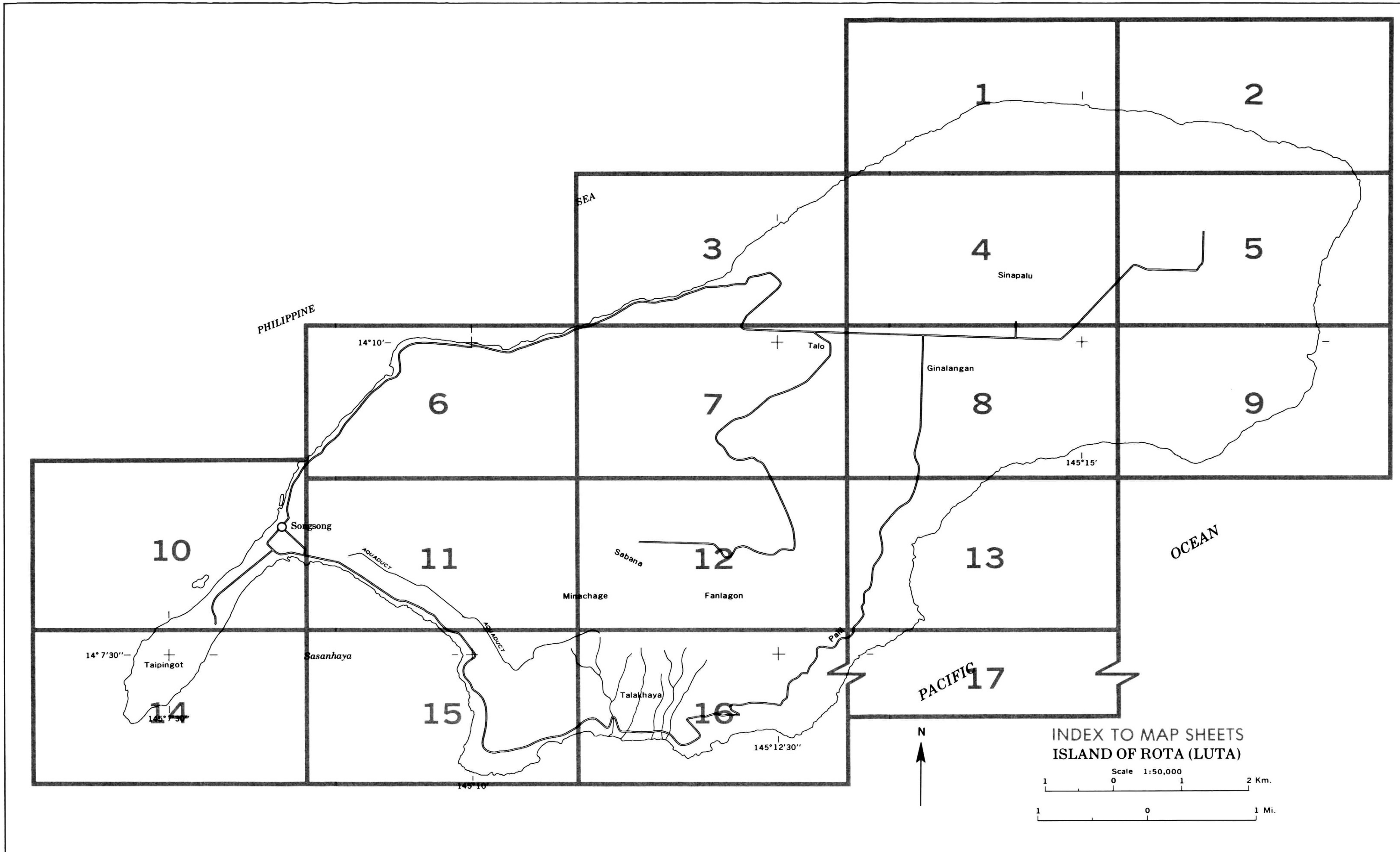
GENERAL SOIL MAP

ISLANDS OF TINIAN AND AGUIJAN

Scale 1: 50,000

1 0 1 2 Km.

1 0 1 Mi.


1
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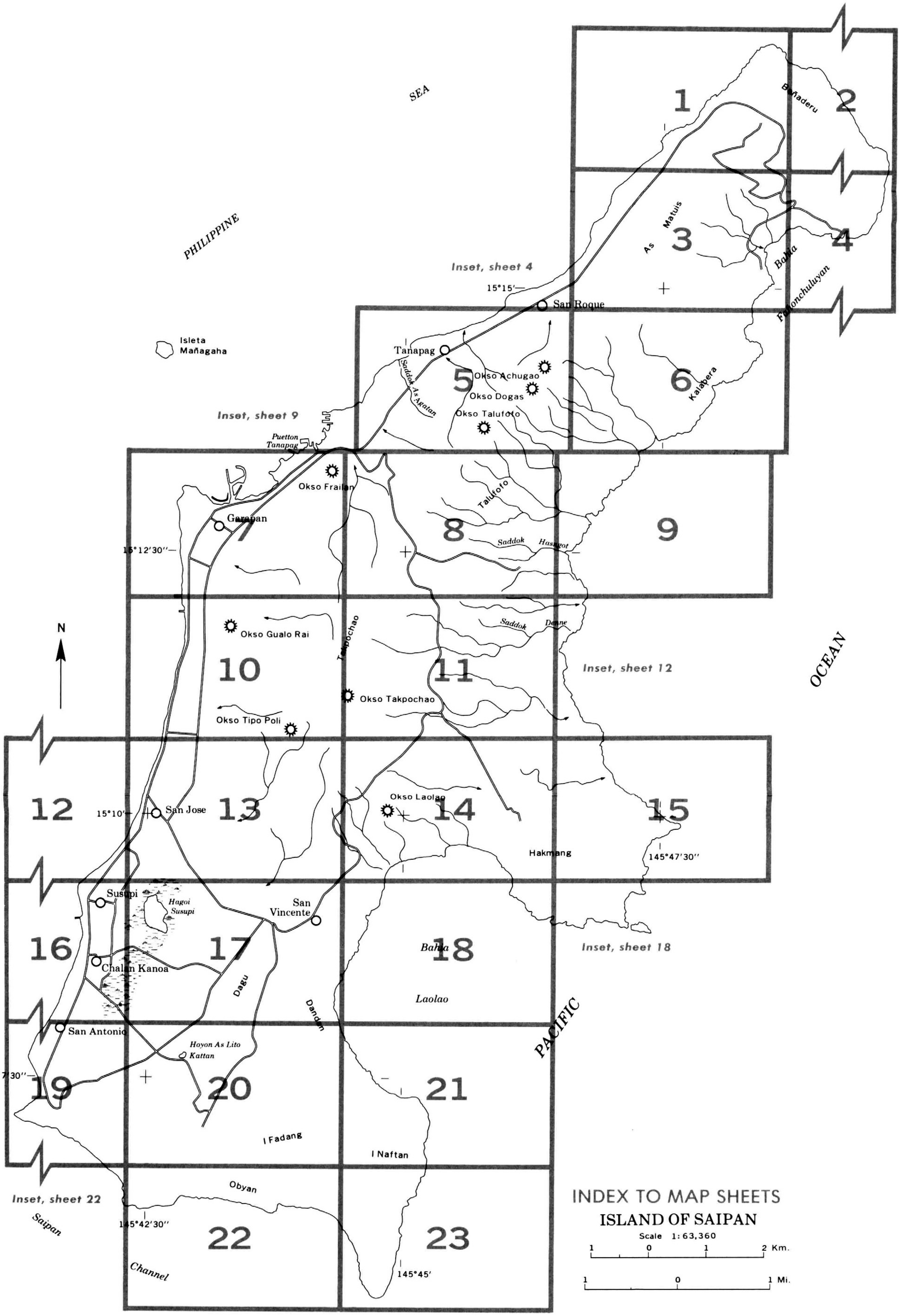
15
16
17
PHILIPPINE
SEA
PACIFIC
OCEAN
Sinapalu
Talo
Ginalangan
Songsong
AQUADUCT
AQUADUCT
Sabana
Minachage
Fanlagon
Pala
Sasanhaya
Taipingot
Talakhaya
14°10′
14° 7′30″
145°15′
145°12′30″
145°10′
145°7′30″
N
INDEX TO MAP SHEETS
ISLAND OF ROTA (LUTA)
Scale 1:50,000
1 0 1 2 Km.
1 0 1 Mi.



INDEX TO MAP SHEETS

ISLAND OF SAIPAN

Scale 1:63,360

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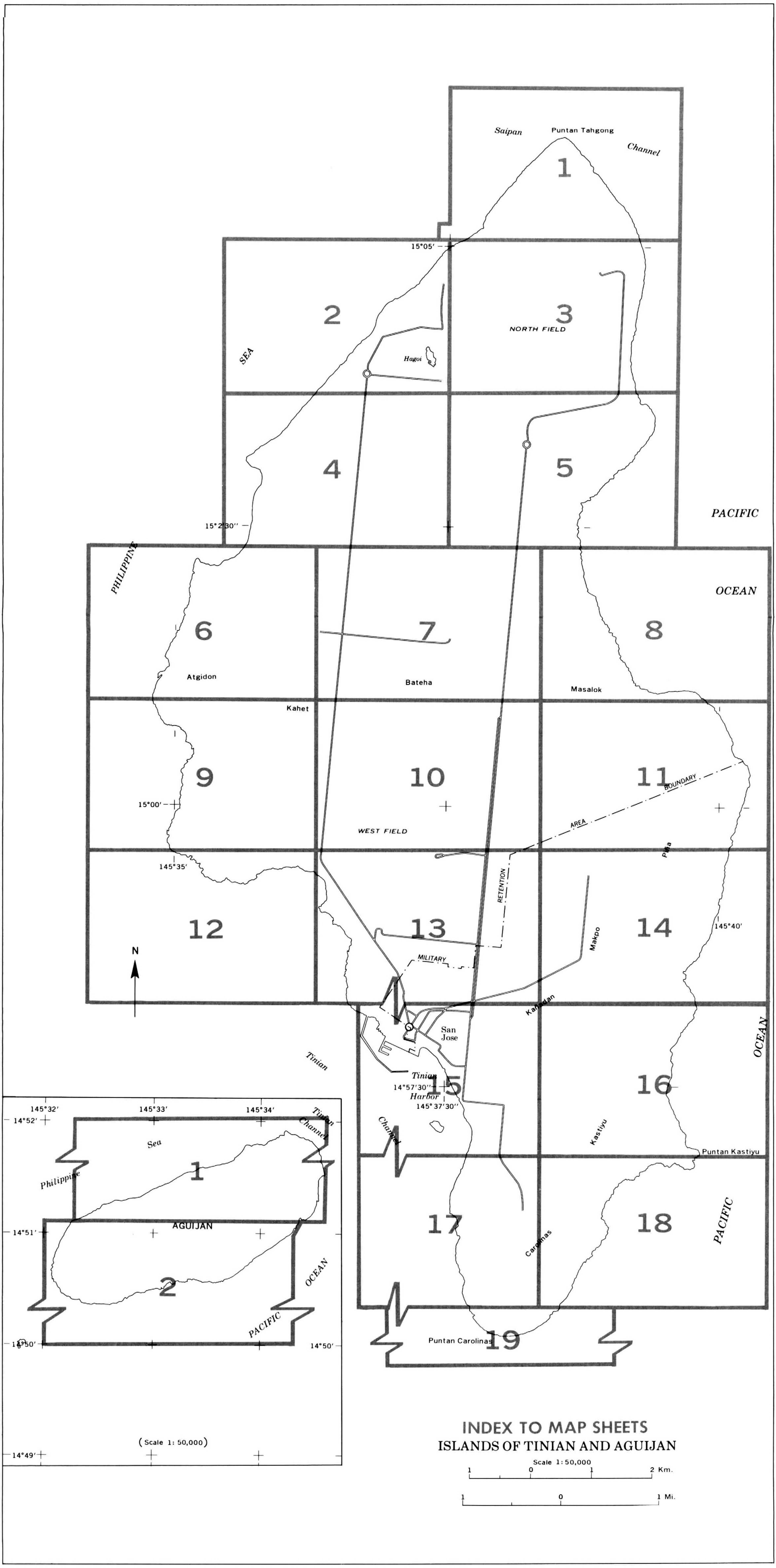
1 0 1 Mi.



INDEX TO MAP SHEETS
ISLANDS OF TINIAN AND AGUIJAN

SOIL LEGEND

SYMBOL	NAME
1	Agfayan Variant-Rock outcrop complex, 15 to 30 percent slopes
2	Agfayan Variant-Rock outcrop complex, 30 to 60 percent slopes
3	Akina-Badland Complex, 15 to 30 percent slopes
4	Akina-Badland Complex, 30 to 60 percent slopes
5	Banaderu clay loam, 3 to 5 percent slopes
6	Banaderu clay loam, 5 to 15 percent slopes
7	Banaderu-Rock outcrop complex, 5 to 15 percent slopes
8	Banaderu-Rock outcrop complex, 15 to 30 percent slopes
9	Chacha clay, drained, 0 to 5 percent slopes
10	Chinen clay loam, 0 to 5 percent slopes
11	Chinen clay loam, 5 to 15 percent slopes
12	Chinen clay loam, 15 to 30 percent slopes
13	Chinen very gravelly sandy loam, 0 to 5 percent slopes
14	Chinen very gravelly sandy loam, 5 to 15 percent slopes
15	Chinen-Rock outcrop complex, 3 to 15 percent slopes
16	Chinen-Rock outcrop complex, 15 to 30 percent slopes
17	Chinen-Urban land complex, 0 to 5 percent slopes
18	Chinen-Urban land complex, 5 to 15 percent slopes
19	Dandan-Chinen complex, 0 to 5 percent slopes
20	Dandan-Chinen complex, 5 to 15 percent slopes
21	Dandan-Chinen-Pits complex, 0 to 5 percent slopes
22	Dandan-Chinen-Pits complex, 5 to 15 percent slopes
23	Dandan-Saipan clays, 0 to 5 percent slopes
24	Dandan-Saipan clays, 5 to 15 percent slopes
25	Inarajan clay, 0 to 5 percent slopes
26	Kagman clay, 0 to 5 percent slopes
27	Kagman clay, 5 to 15 percent slopes
28	Kagman very gravelly sandy loam, 0 to 5 percent slopes
29	Kagman-Urban land complex, 0 to 5 percent slopes
30	Laolao clay, 0 to 5 percent slopes
31	Laolao clay, 5 to 15 percent slopes
32	Laolao clay, 15 to 30 percent slopes
33	Laolao clay, 30 to 60 percent slopes
34	Luta cobbly clay loam, 0 to 5 percent slopes
35	Luta cobbly clay loam, 5 to 15 percent slopes
36	Luta cobbly clay loam, moist, 0 to 5 percent slopes
37	Luta cobbly clay loam, moist, 5 to 15 percent slopes
38	Luta-Rock outcrop complex, 0 to 5 percent slopes
39	Luta-Rock outcrop complex, 5 to 15 percent slopes
40	Luta-Rock outcrop complex, 15 to 30 percent slopes
41	Mesei Variant muck, 0 to 2 percent slopes
42	Rock outcrop-Takpochao complex, 60 to 99 percent slopes
43	Saipan clay, 0 to 5 percent slopes
44	Saipan clay, 5 to 15 percent slopes
45	Saipan very gravelly sandy loam, 0 to 5 percent slopes
46	Saipan very gravelly sandy loam, 5 to 15 percent slopes
47	Saipan-Rock outcrop complex, 0 to 5 percent slopes
48	Shioya loamy sand, 0 to 3 percent slopes
49	Shioya-Urban land complex, 0 to 3 percent slopes
50	Takpochao-Rock outcrop complex, 3 to 15 percent slopes
51	Takpochao-Rock outcrop complex, 15 to 30 percent slopes
52	Takpochao-Rock outcrop complex, 30 to 60 percent slopes
53	Takpochao Variant-Shioya complex, 1 to 10 percent slopes

CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Minor civil division
- Reservation (national forest or park, state forest or park, and large airport)
- Land grant
- Limit of soil survey (label)
- Field sheet matchline and neatline

AD HOC BOUNDARY (label) — Swift Airport

- Small airport, airfield, park, oilfield, cemetery, or flood pool — FLOOD POOL LINE

STATE COORDINATE TICK

LAND DIVISION CORNER (sections and land grants)

ROADS

- Divided (median shown if scale permits)
- Other roads
- Trail

ROAD EMBLEM & DESIGNATIONS

- Interstate — 21
- Federal — 173
- State — 28
- County, farm or ranch — 1283

RAILROAD

POWER TRANSMISSION LINE (normally not shown)

PIPE LINE (normally not shown)

FENCE (normally not shown)

LEVEES

- Without road
- With road
- With railroad

DAMS

- Large (to scale)
- Medium or Small — water, w

PITS

- Gravel pit
- Mine or quarry

MISCELLANEOUS CULTURAL FEATURES

- Farmstead, house (omit in urban areas)
- Church
- School
- Indian mound (label) — Indian Mound
- Located object (label) — Tower
- Tank (label) — Gas
- Wells, oil or gas
- Windmill
- Kitchen midden

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
- Drainage end
- Canals or ditches
  - Double-line (label) — CANAL
  - Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial — water, w
- Intermittent — int, i

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS — 2, 10

ESCARPMENTS

- Bedrock (points down slope)
- Other than bedrock (points down slope)

SHORT STEEP SLOPE

GULLY

DEPRESSION OR SINK

SOIL SAMPLE (normally not shown) — S

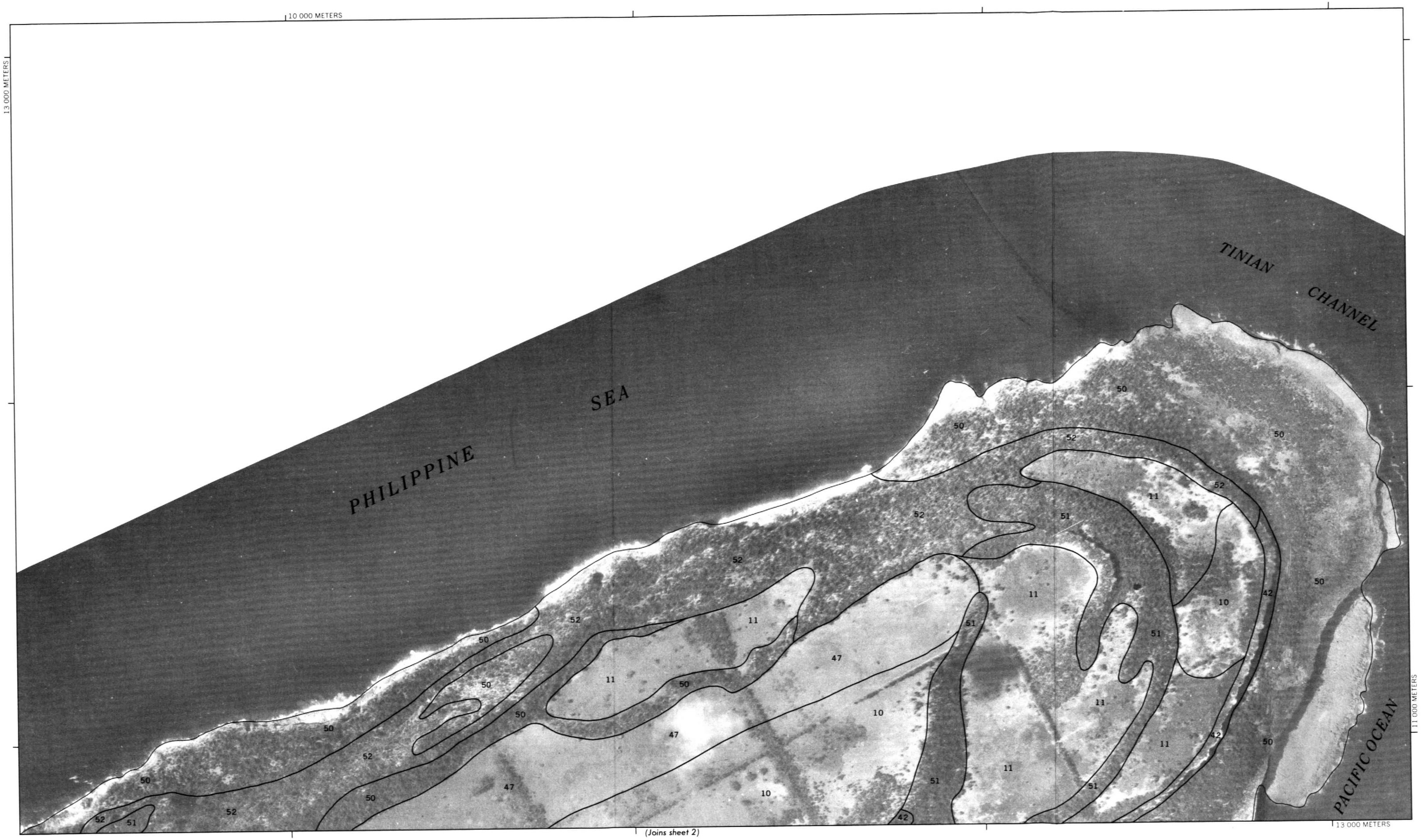
MISCELLANEOUS

- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scabby spot (sodic)
- Dumps and other similar non soil areas
- Prominent hill or peak
- Rock outcrop (includes sandstone and shale)
- Saline spot
- Sandy spot
- Severely eroded spot
- Slide or slip (tips point upslope)
- Stony spot, very stony spot

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 1

1

N



1 KILOMETER
50 MILE
SCALE 1:10 000
3000 FEET
1000 METERS

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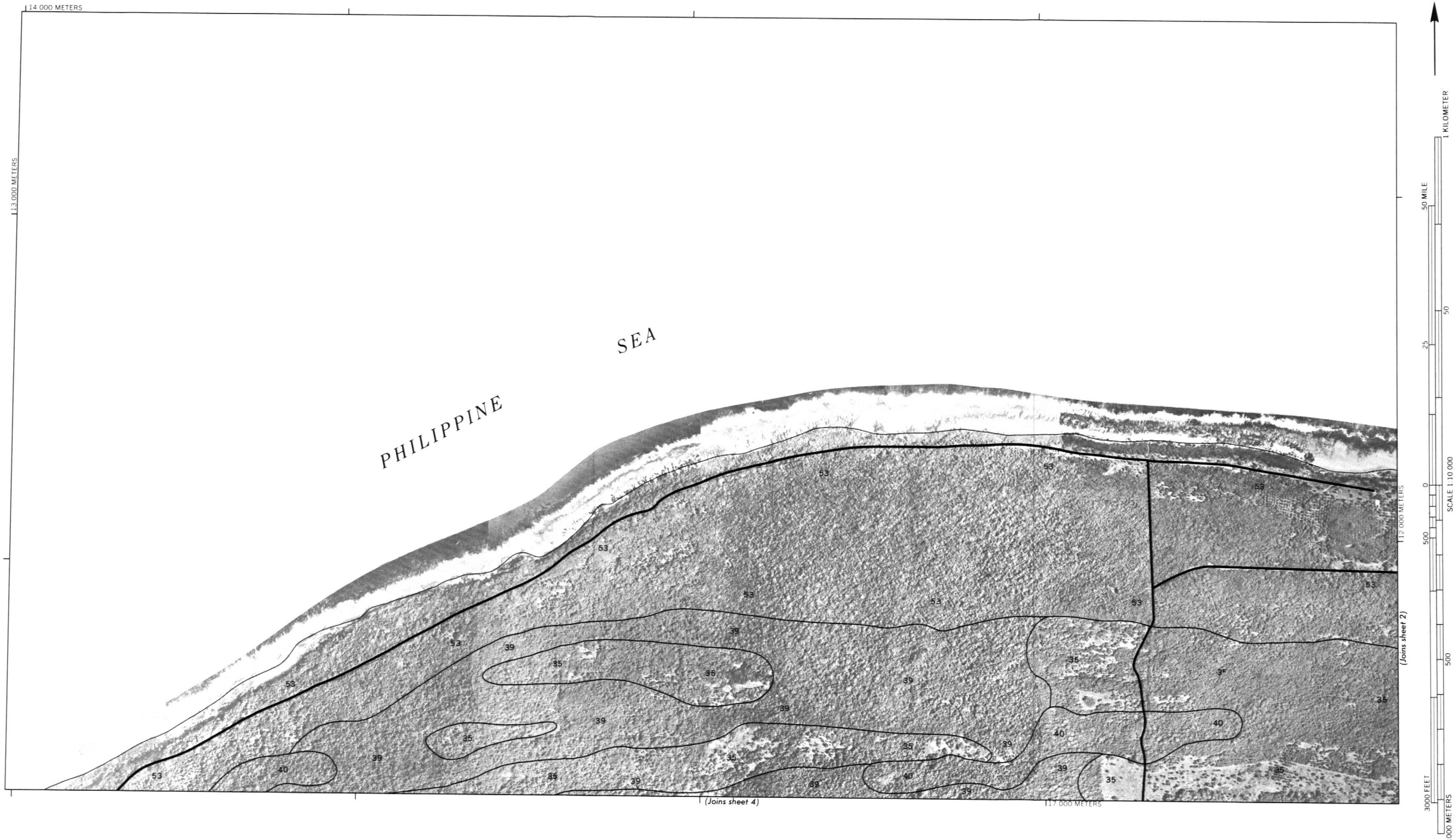
ISLAND OF AGUIJAN, NO. 1

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 1



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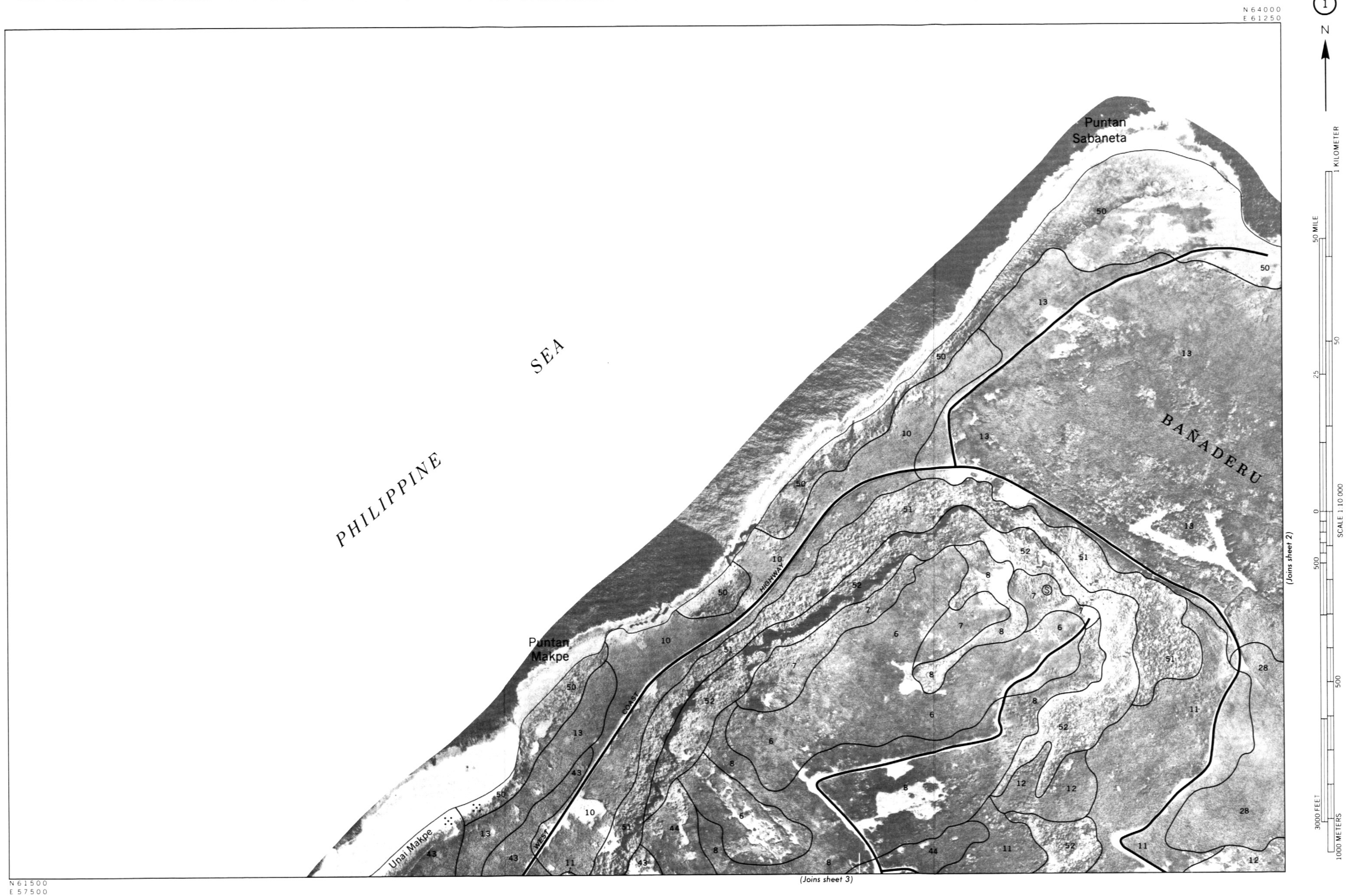
ISLAND OF ROTA, NO. 1

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 1



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ISLAND OF SAIPAN, NO. 1

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 1

ISLAND OF TINIAN NO. 1

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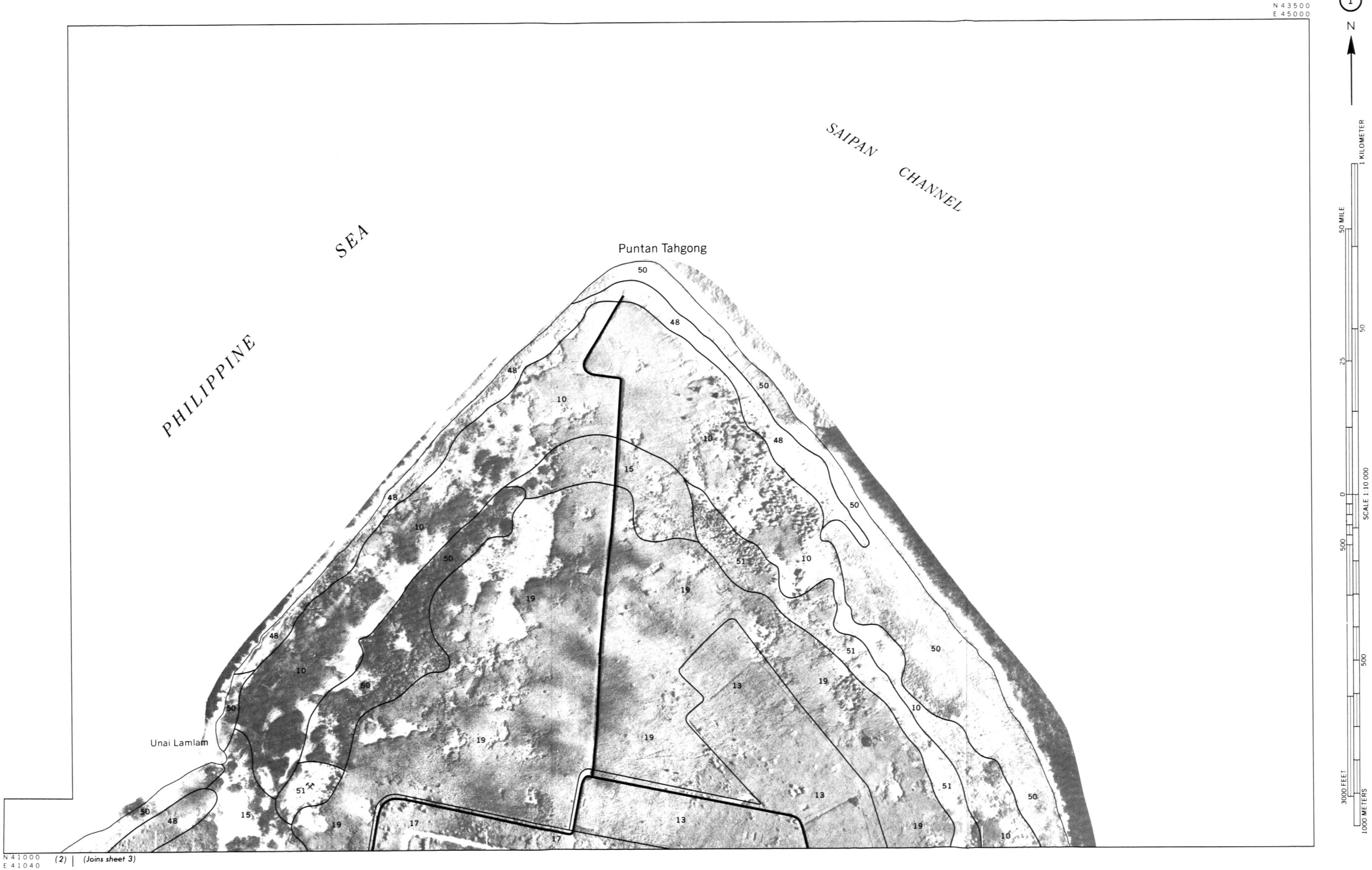
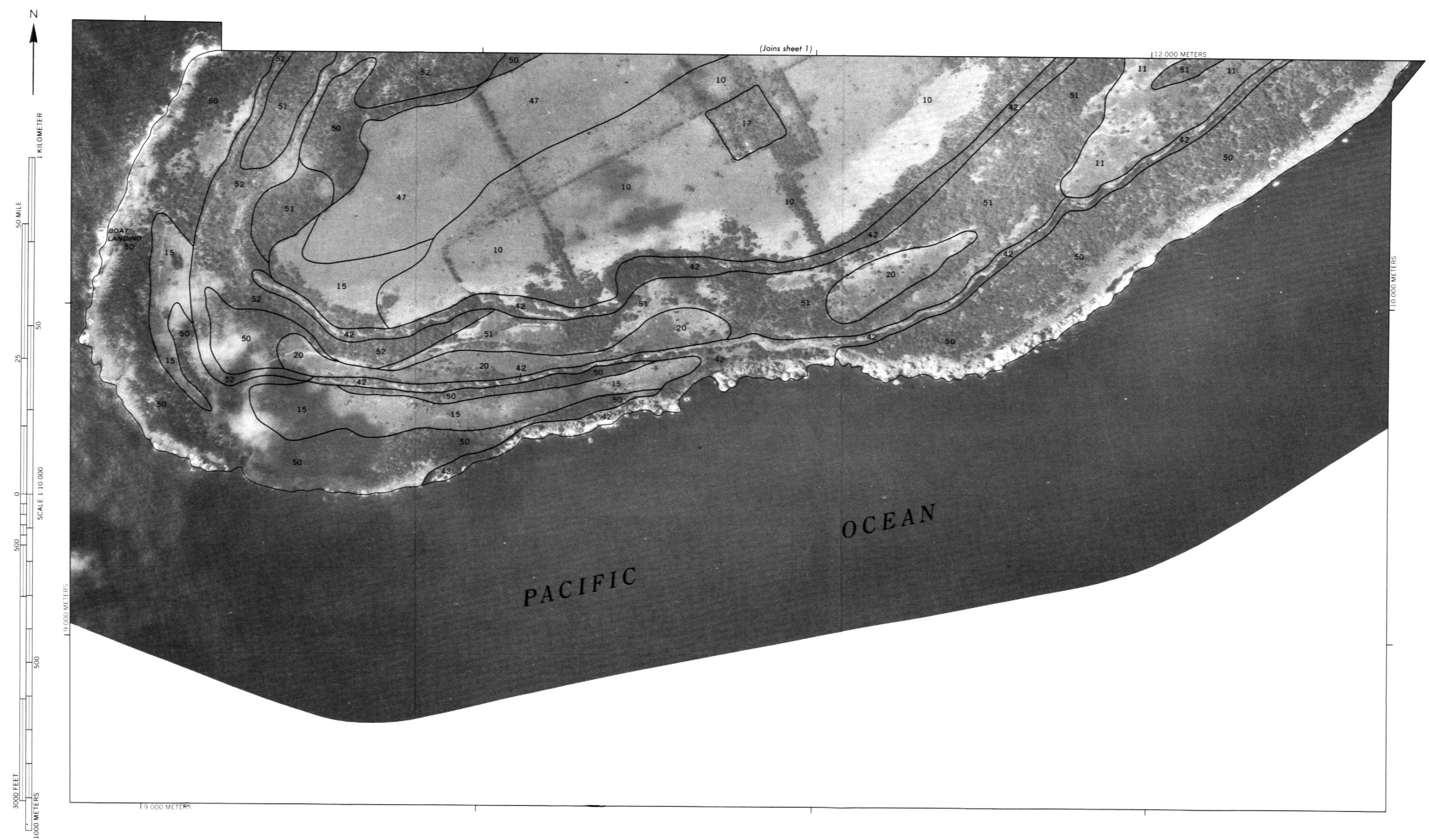


SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 2



ISLAND OF AGUIJAN, NO. 2

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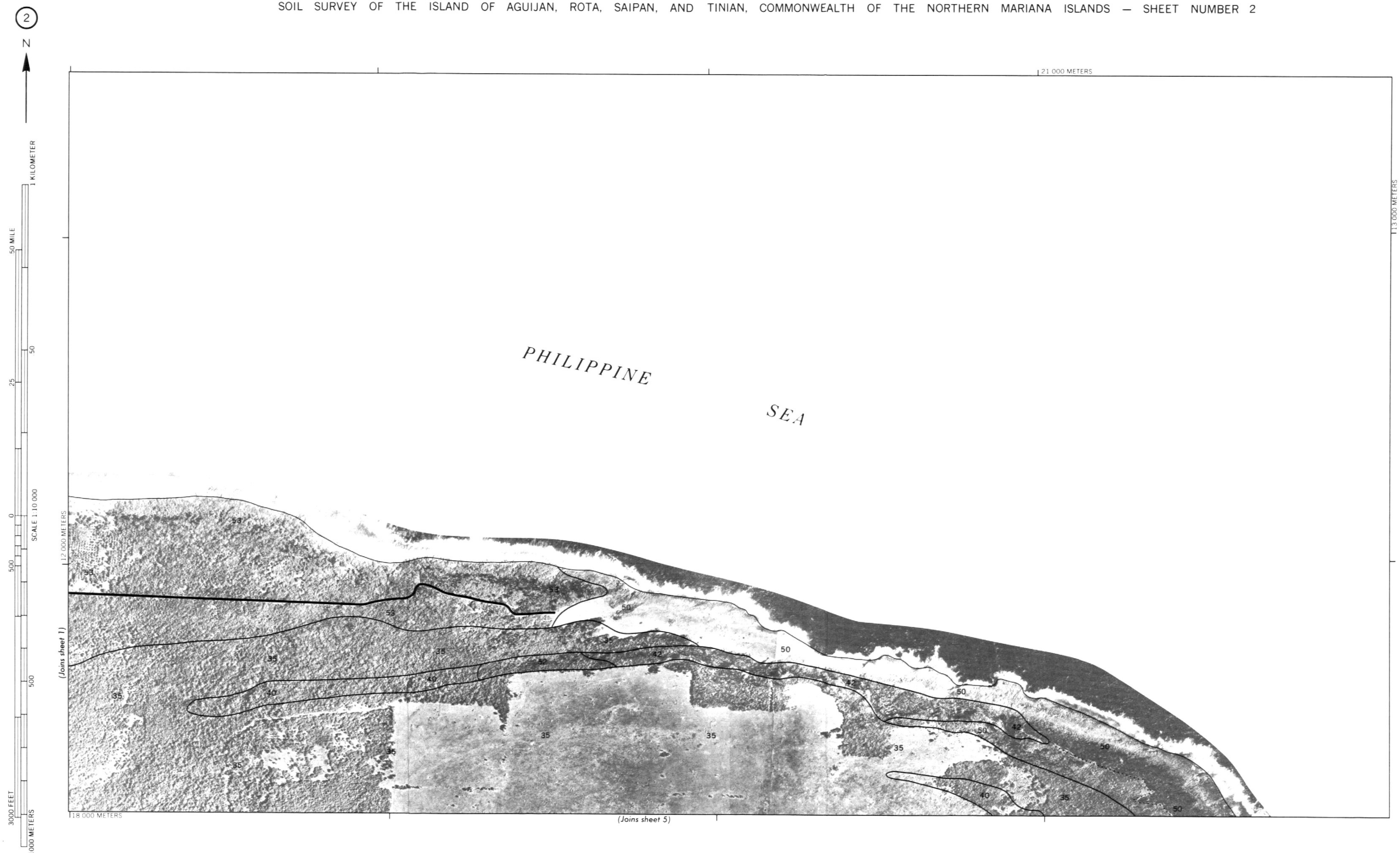

ISLAND OF ROTA, NO. 2

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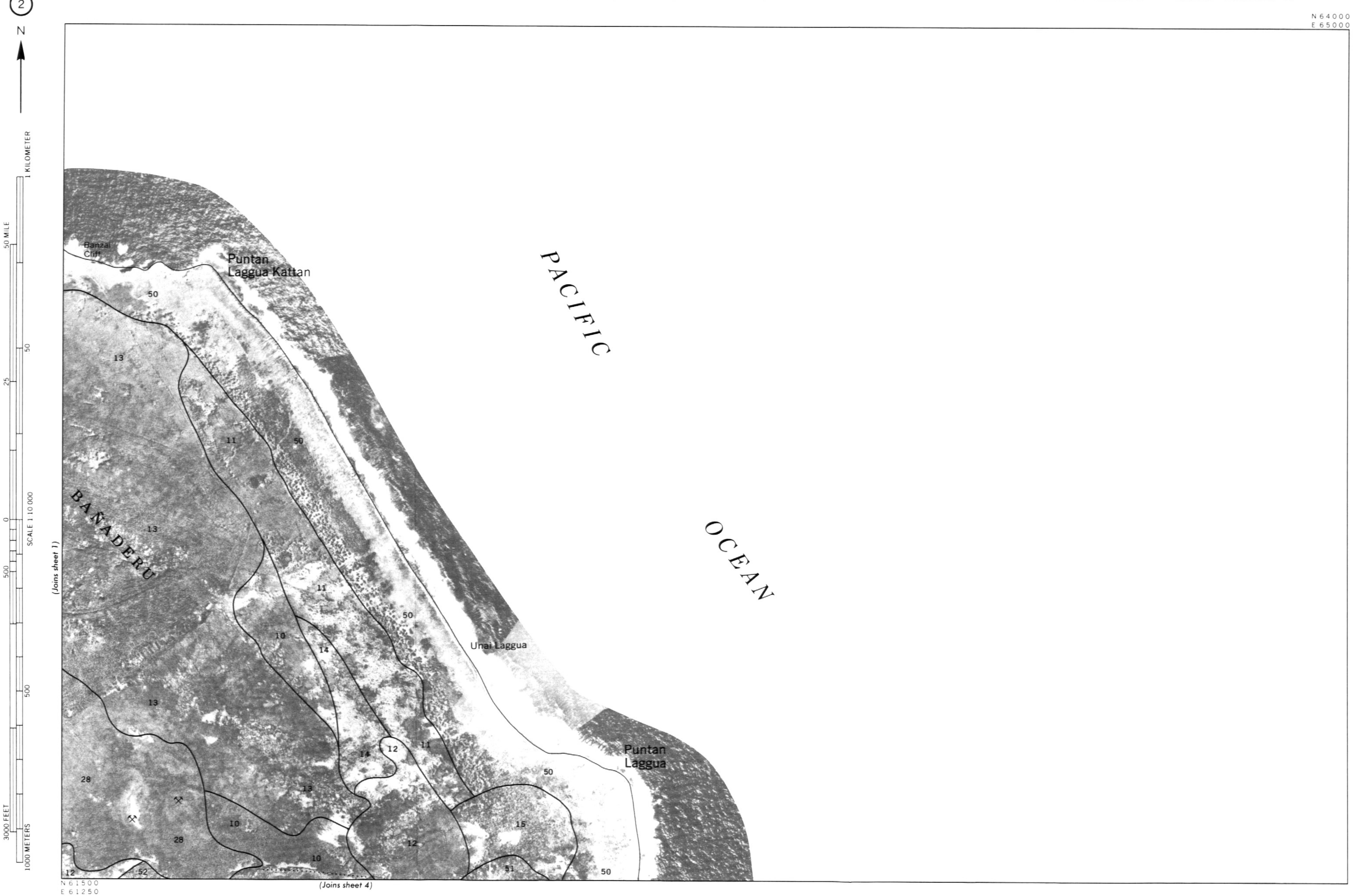
SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 2



ISLAND OF SAIPAN, NO. 2

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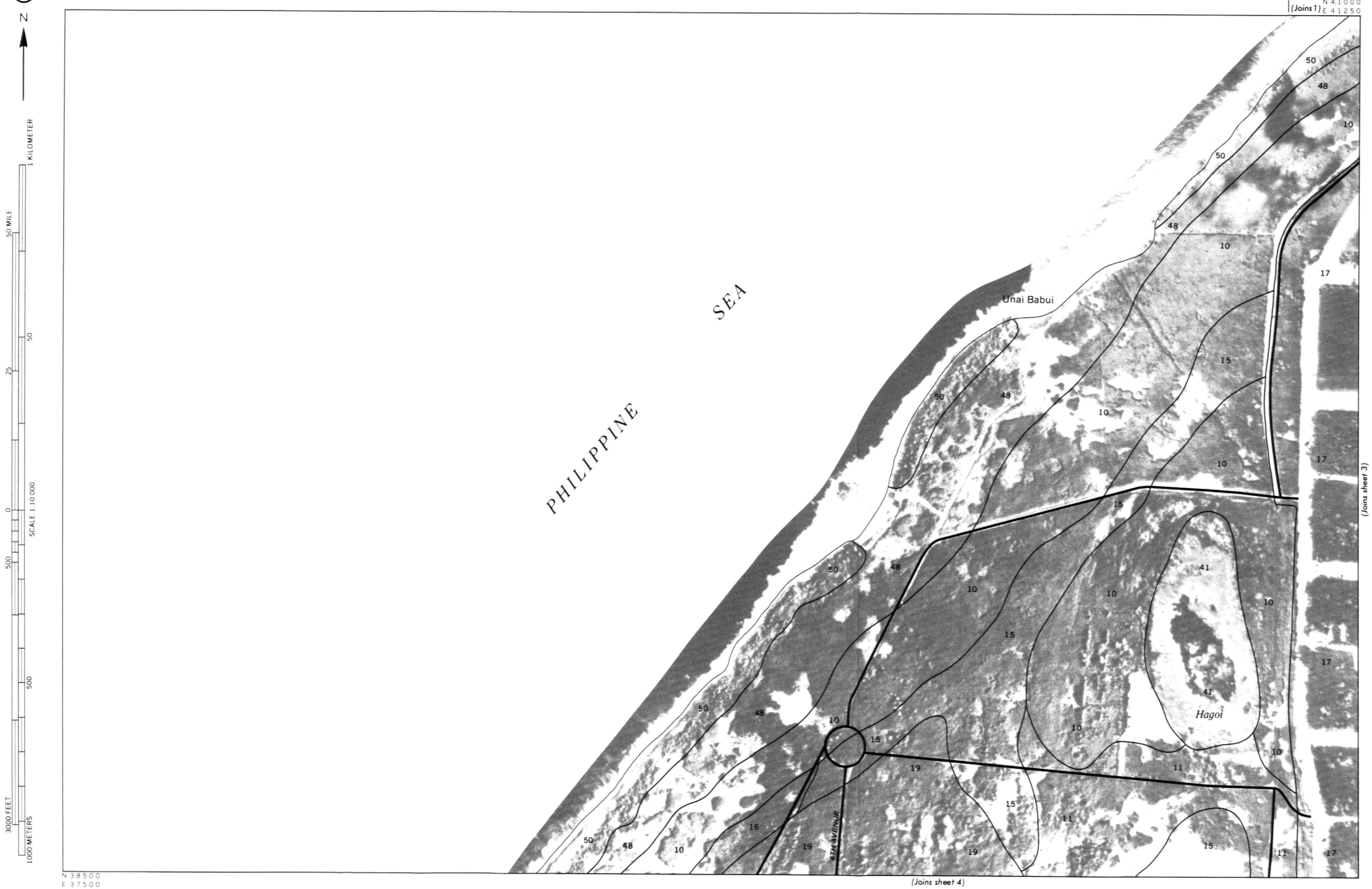
SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 2



ISLAND OF TINIAN NO. 2

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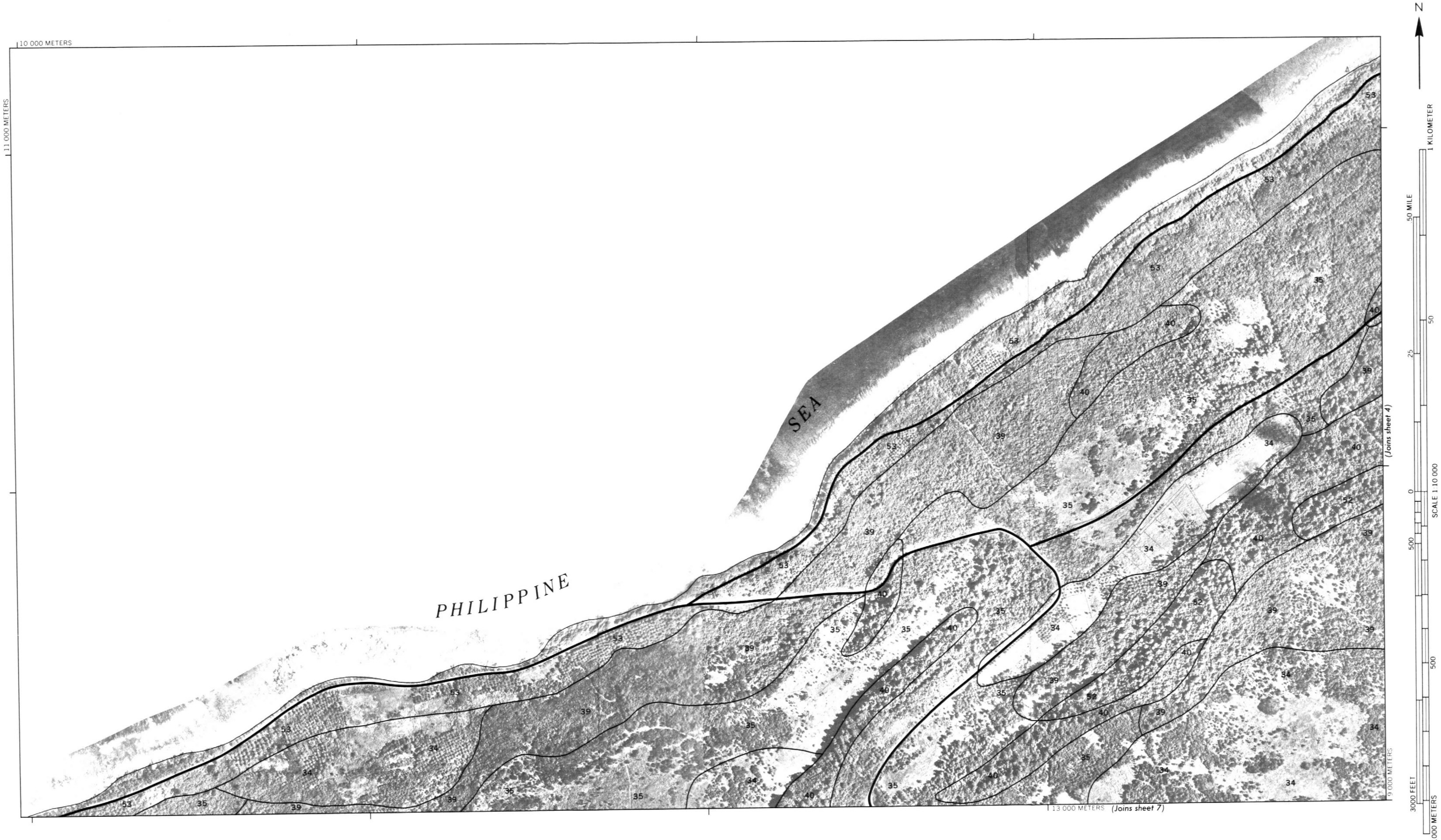
3



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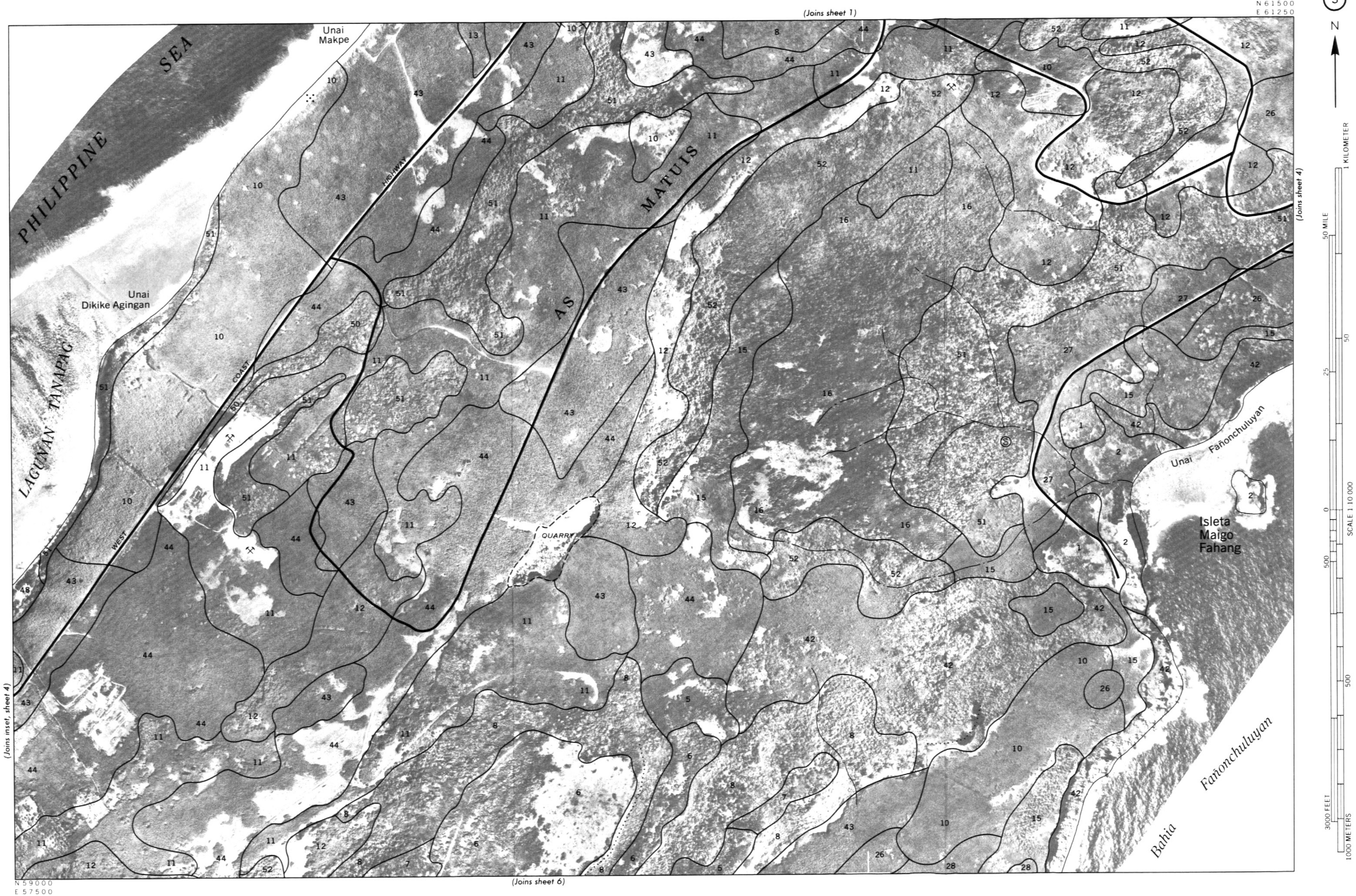
ISLAND OF ROTA, NO. 3

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 3

3



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ISLAND OF SAIPAN, NO. 3

3

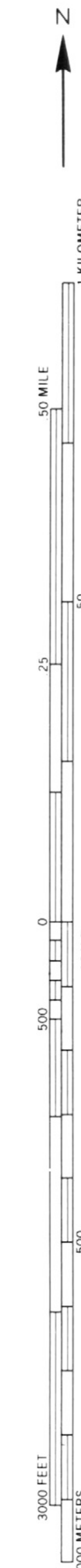
(Joins sheet 1)

N 41000
E 45000

(Joins sheet 2)

(Joins sheet 5)

N 38500
E 41250



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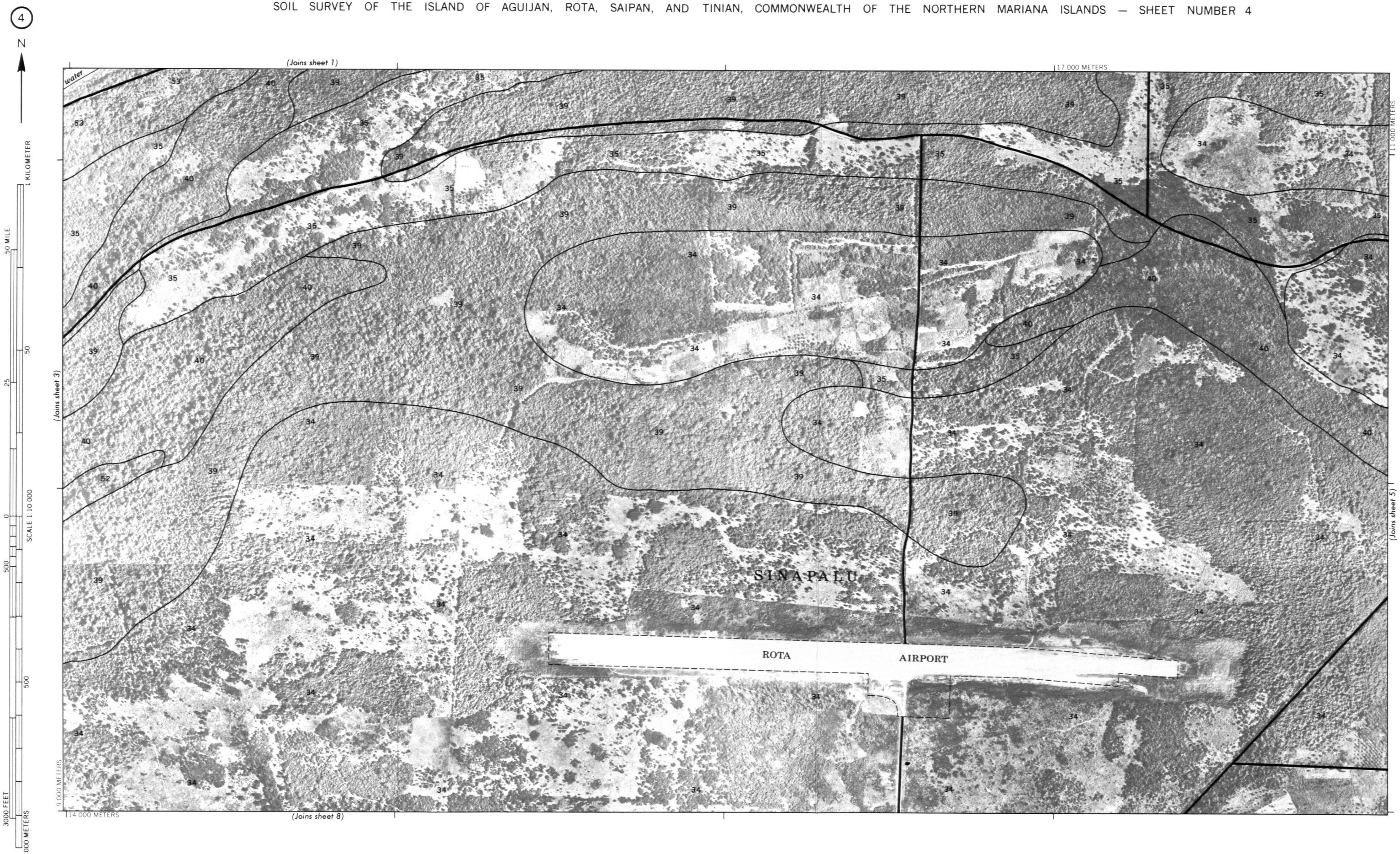
ISLAND OF TINIAN NO. 3



ISLAND OF ROTA, NO. 4

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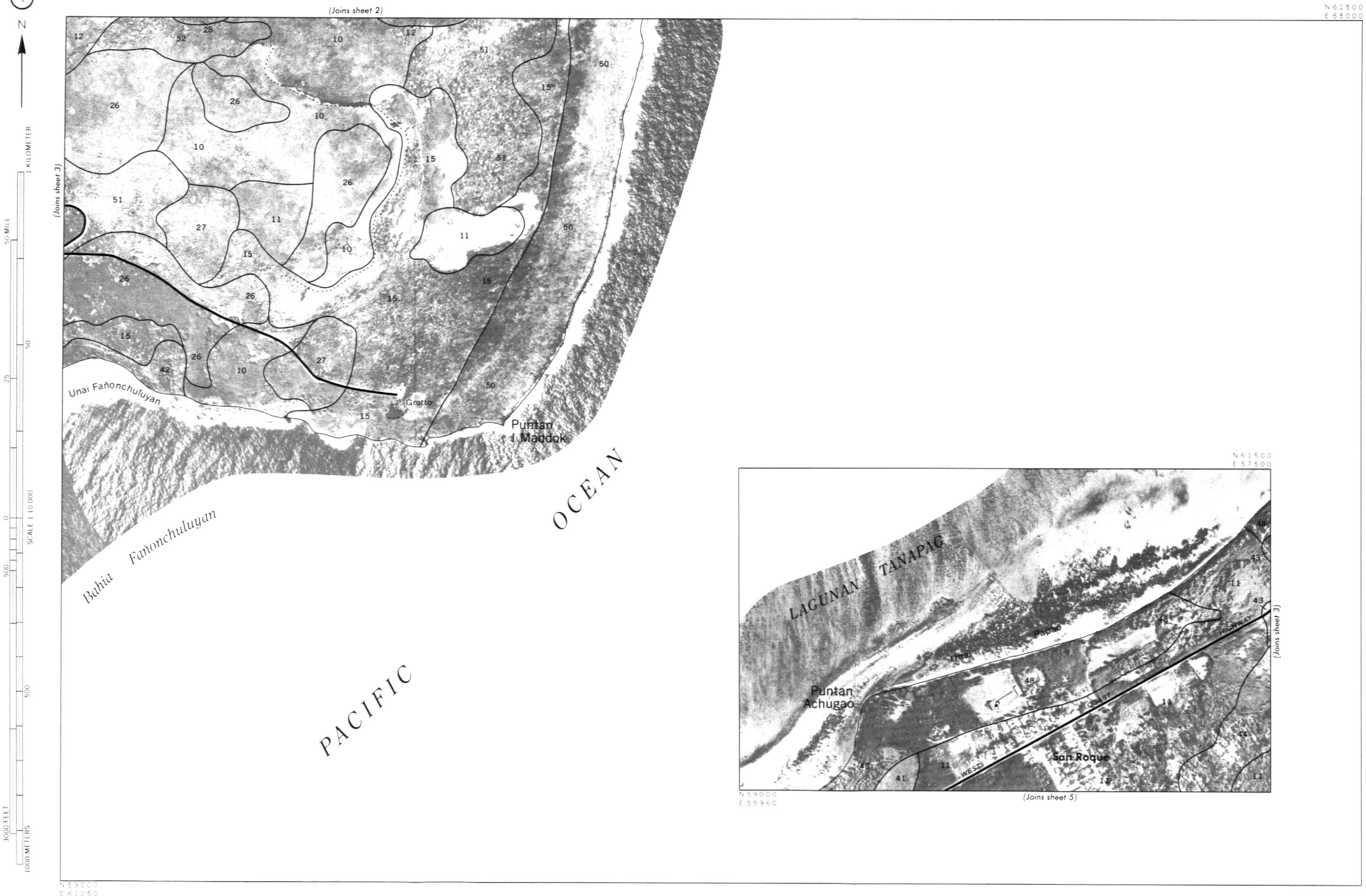
SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 4



ISLAND OF SAIPAN, NO. 4

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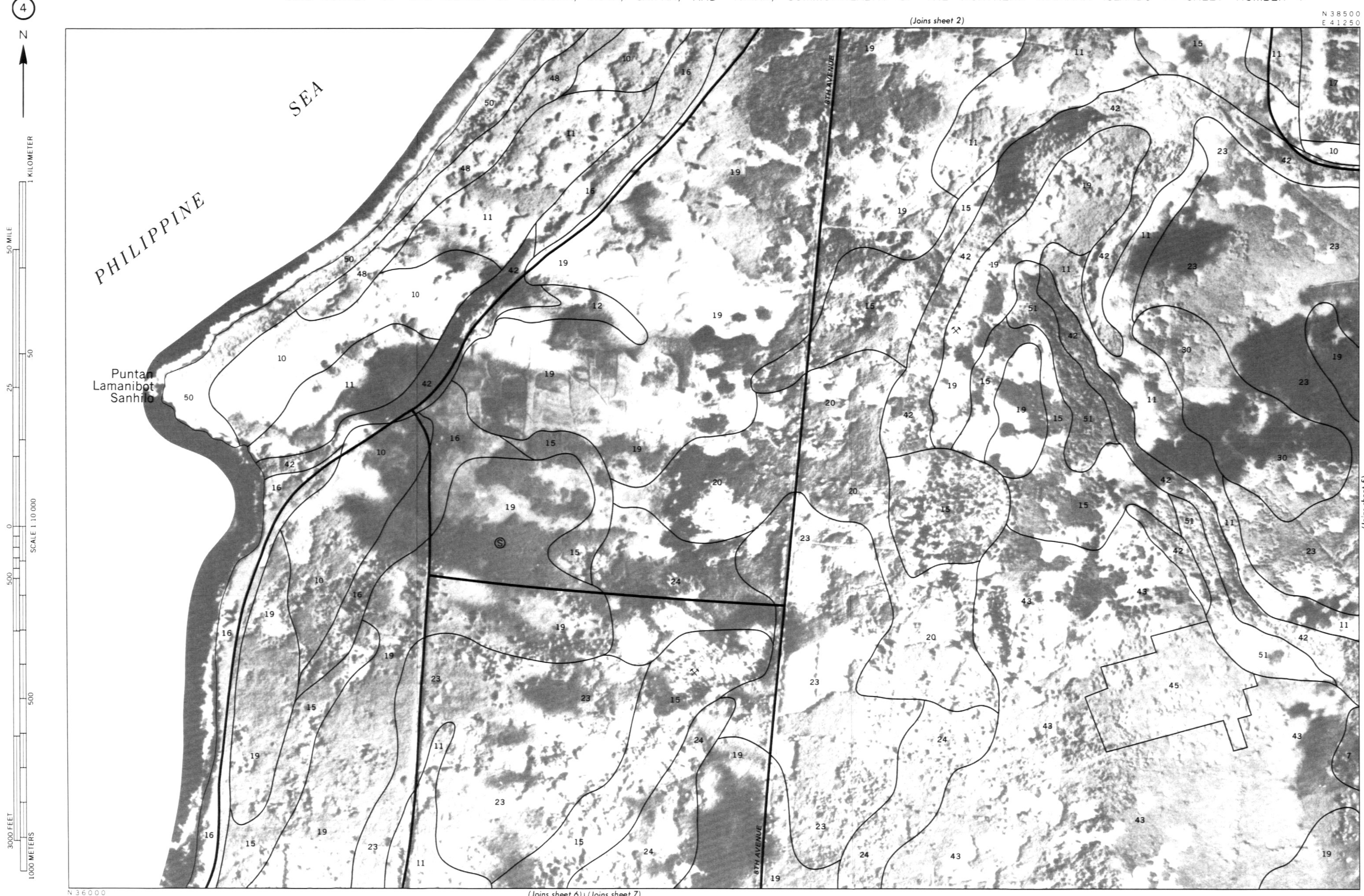

ISLAND OF TINIAN NO. 4

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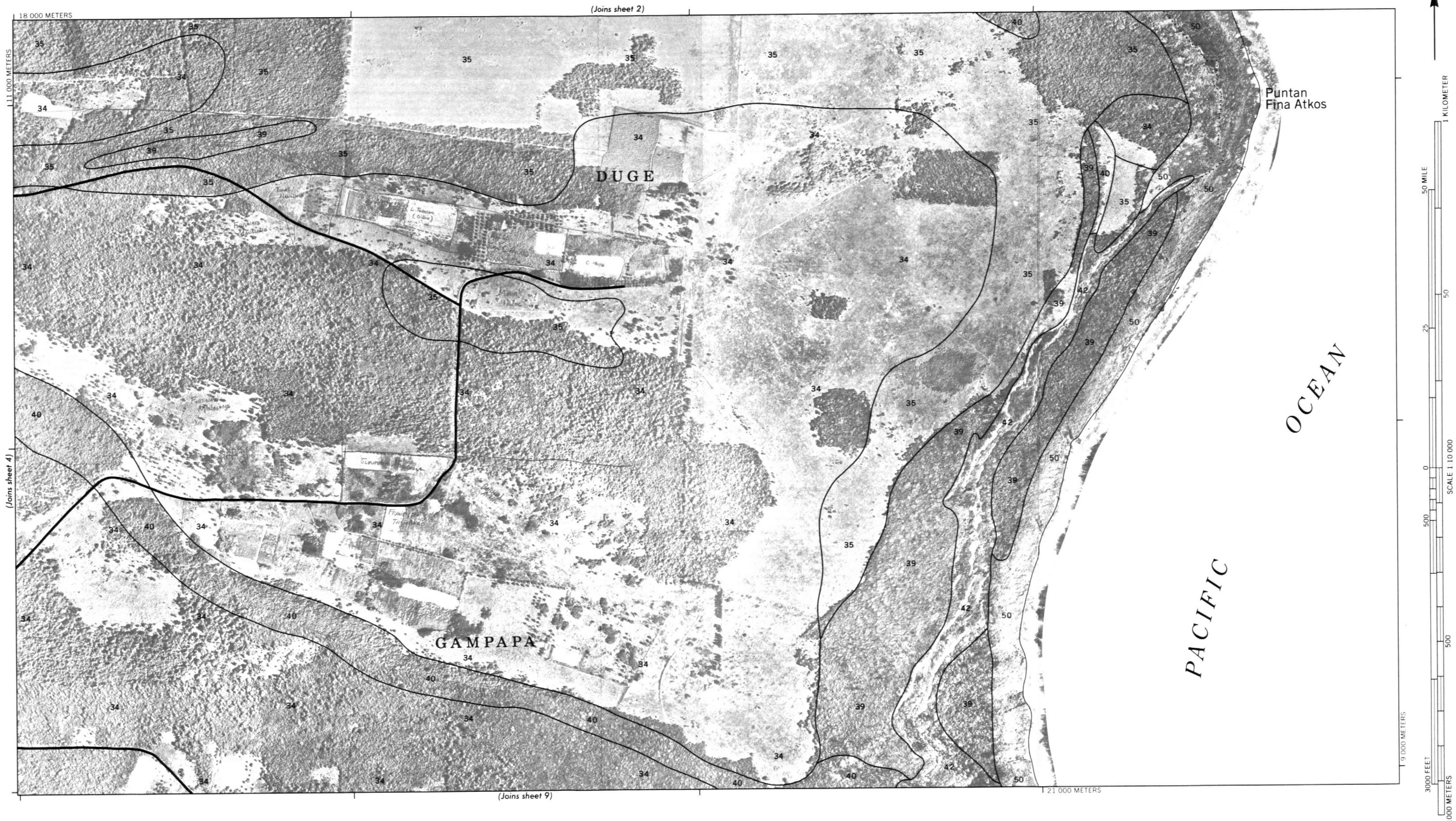
5



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ISLAND OF ROTA, NO. 5

5

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ISLAND OF SAIPAN, NO. 5

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 5

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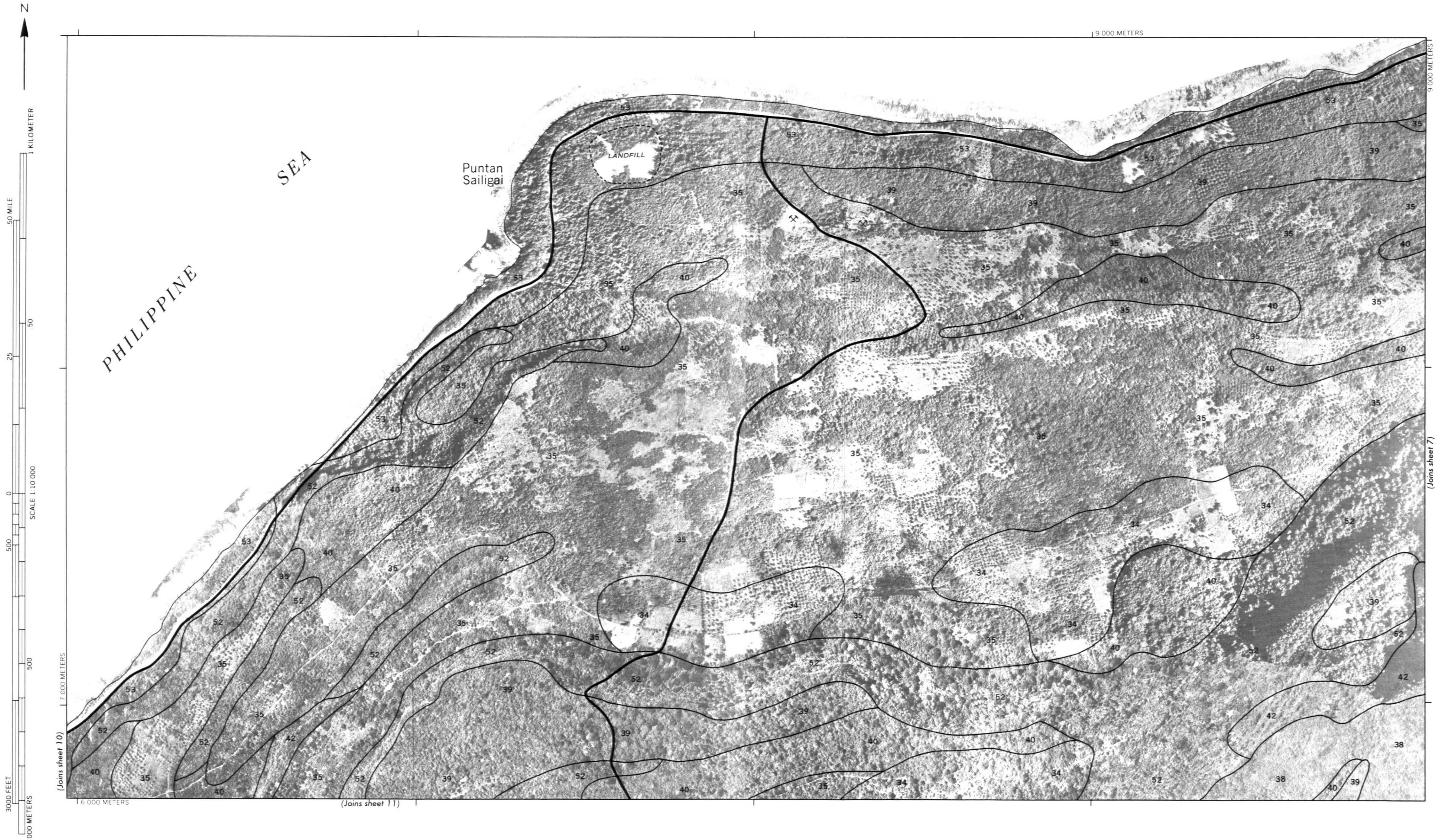
ISLAND OF TINIAN NO. 5

6



ISLAND OF ROTA, NO. 6

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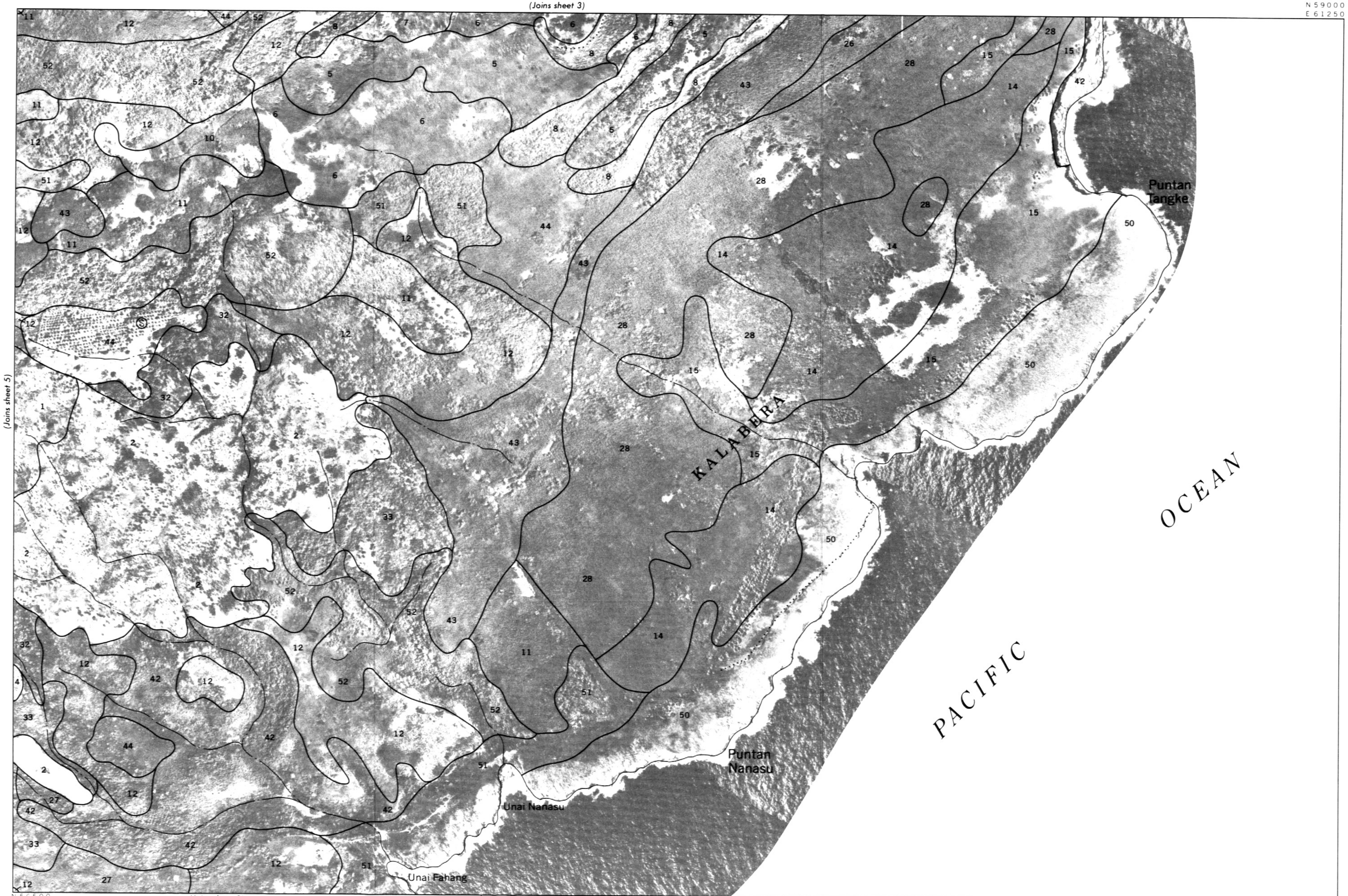
SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 6



N
1 KILOMETER
.50 MILE
SCALE 1:10 000
3000 FEET
1000 METERS

ISLAND OF SAIPAN, NO. 6

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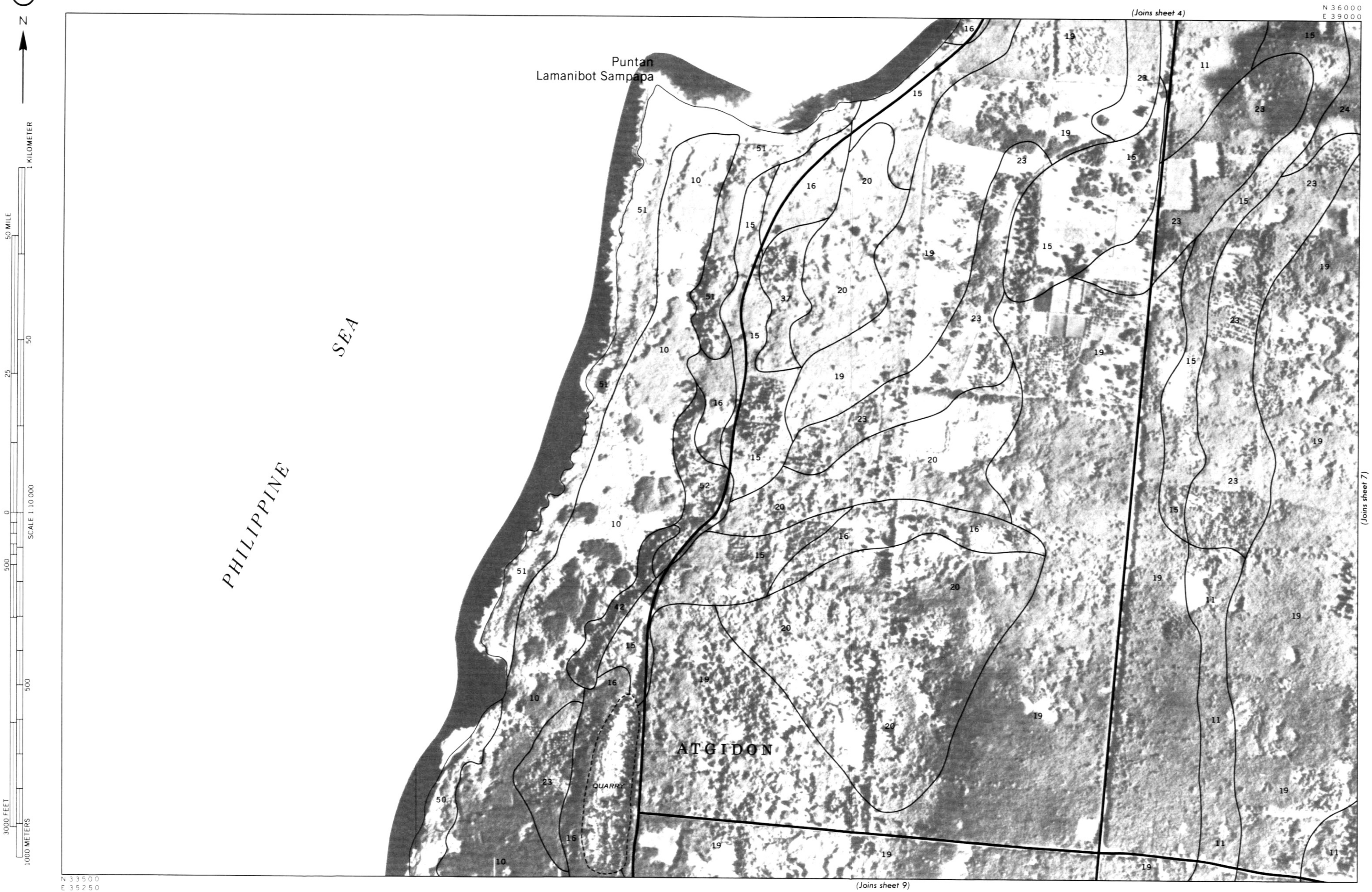
6

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 6



ISLAND OF TINIAN NO. 6

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ISLAND OF ROTA, NO. 7

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ISLAND OF SAIPAN, NO. 7

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 7

ISLAND OF TINIAN NO. 7

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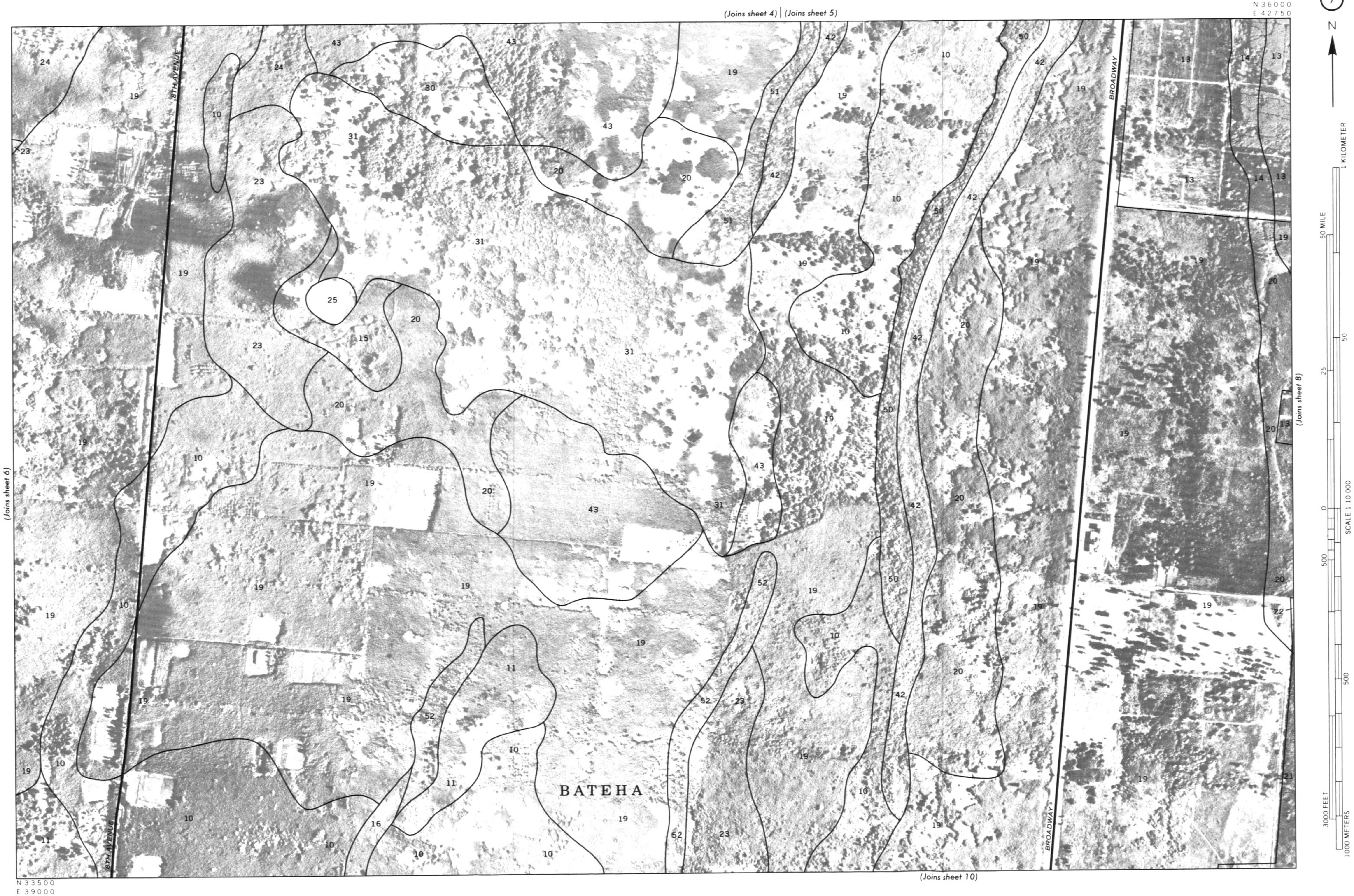
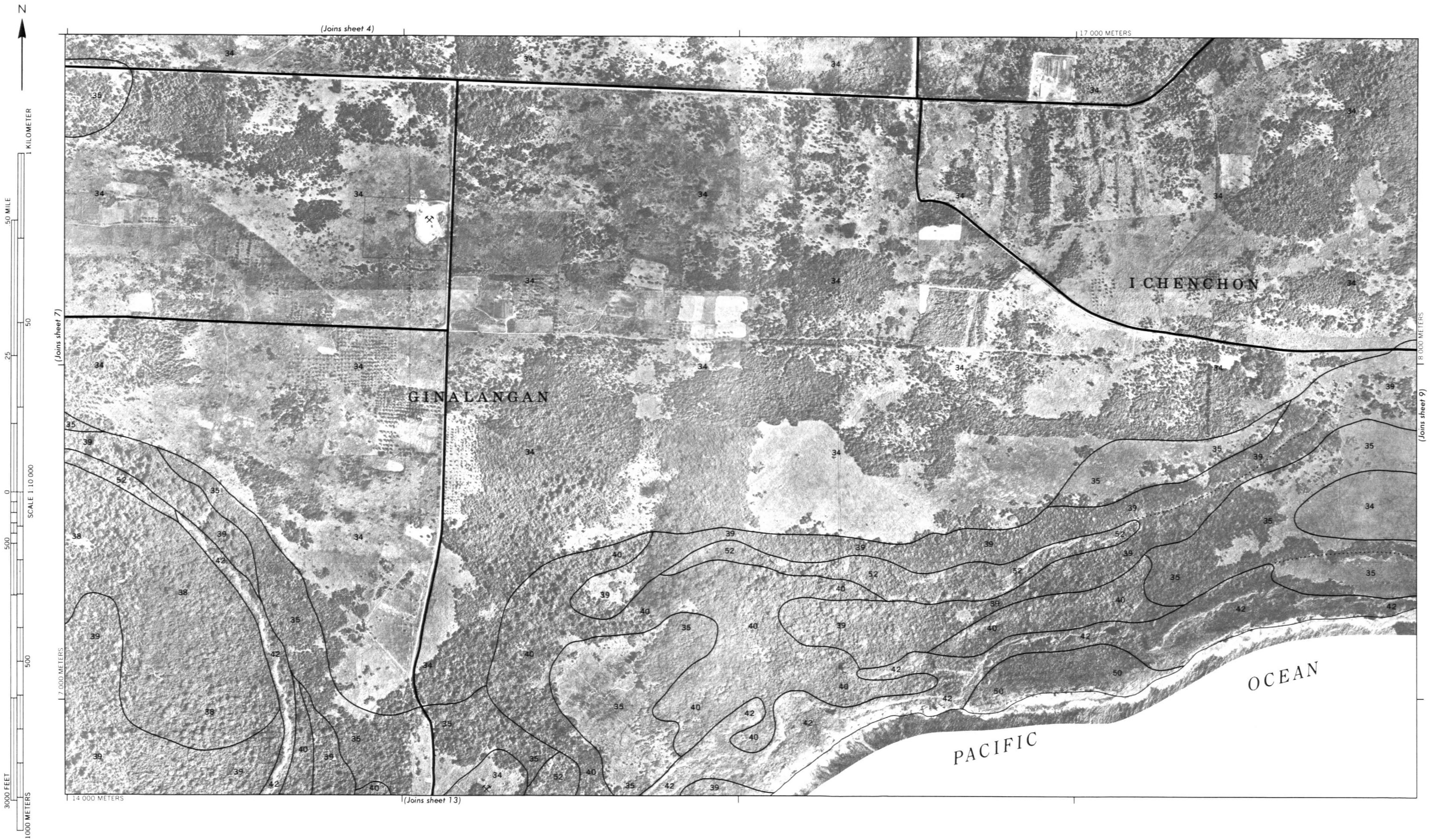


SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 8



ISLAND OF ROTA, NO. 8

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8

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 8

(Joins inset, sheet 9) | (Joins sheet 5)

N 56500
E 57250

N 54000
E 53500

(Joins sheet 11)

N

1 KILOMETER
50 MILE
SCALE 1:10 000
3000 FEET
1000 METERS

ISLAND OF SAIPAN, NO. 8

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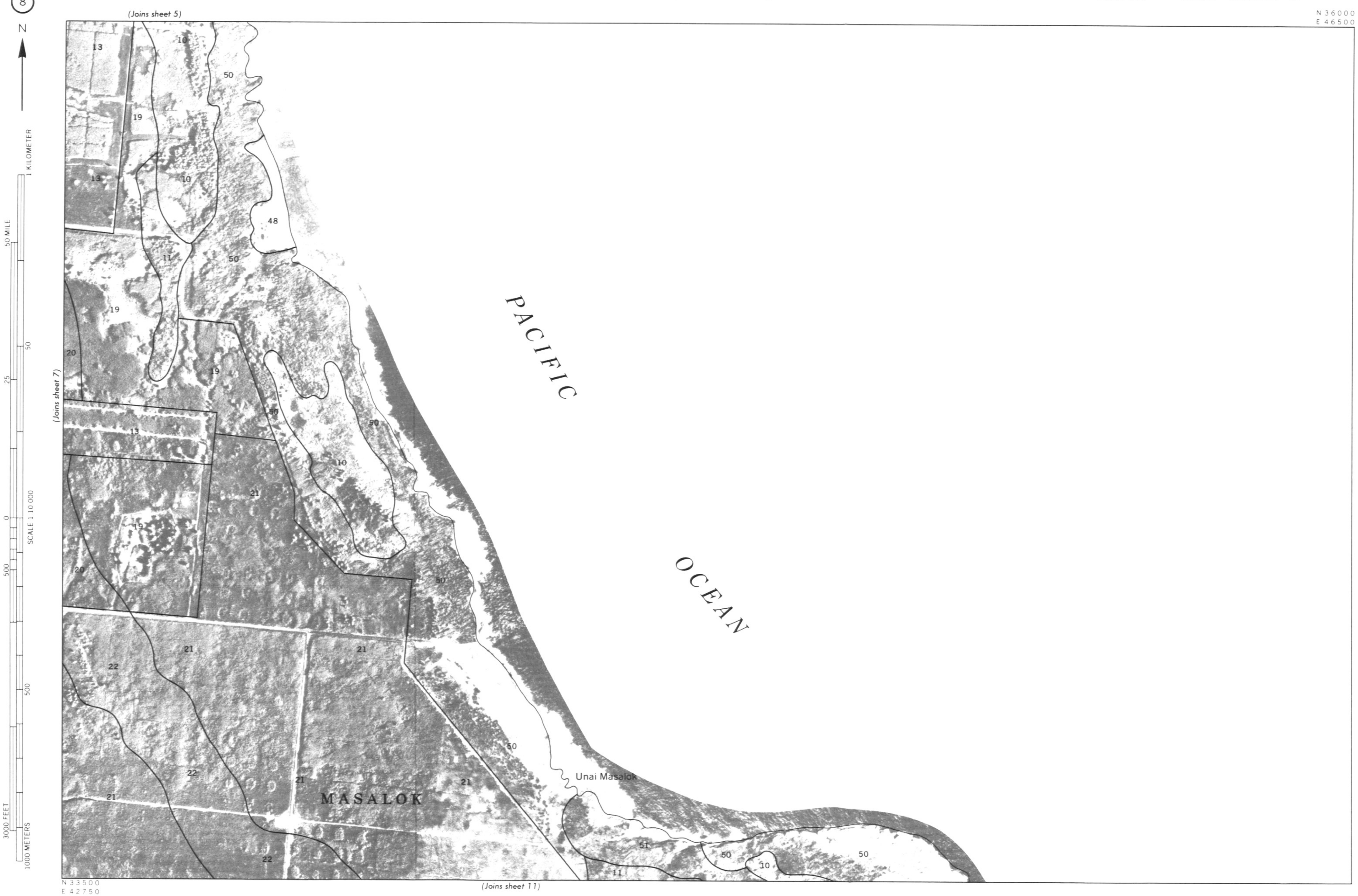

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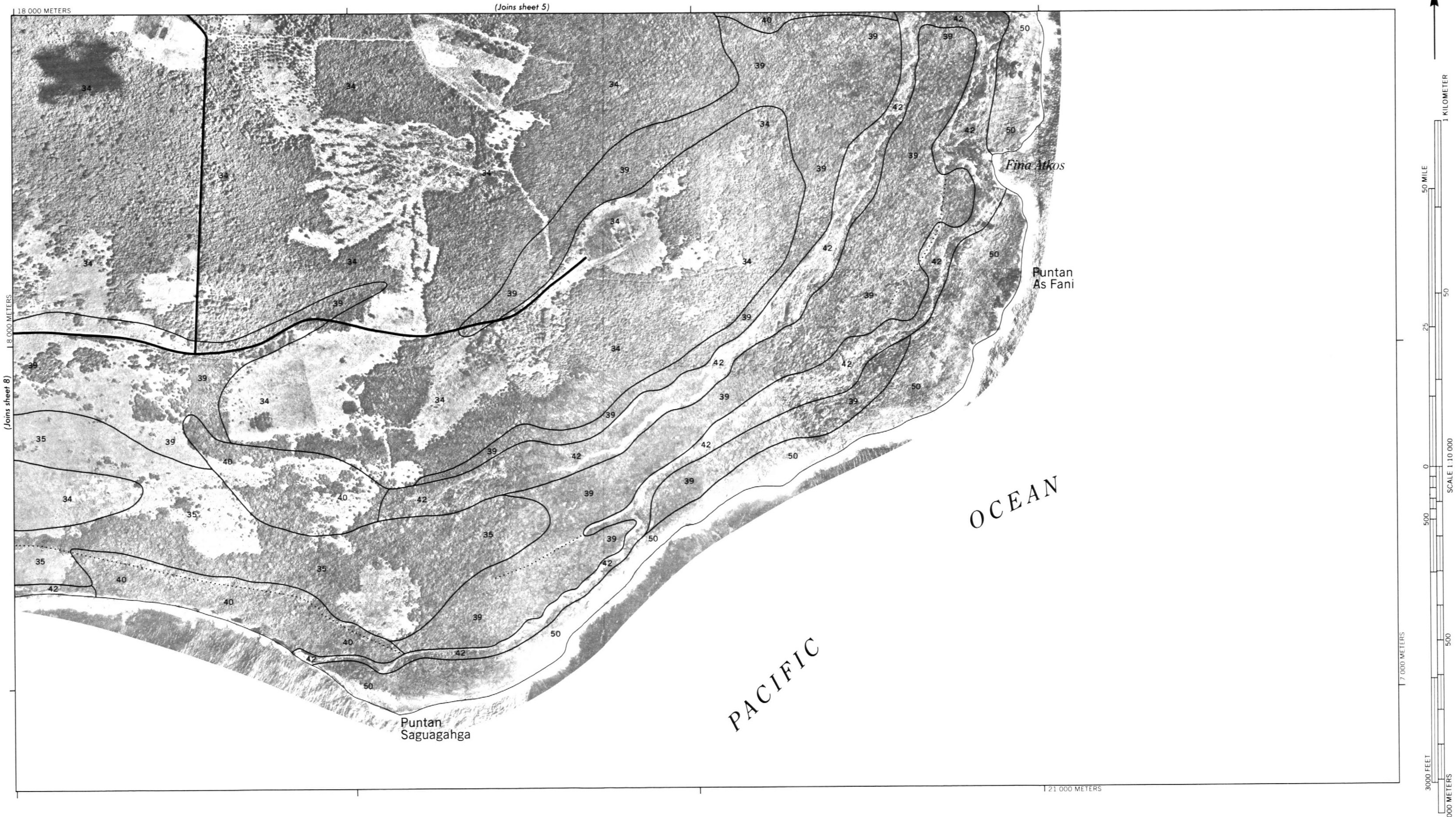
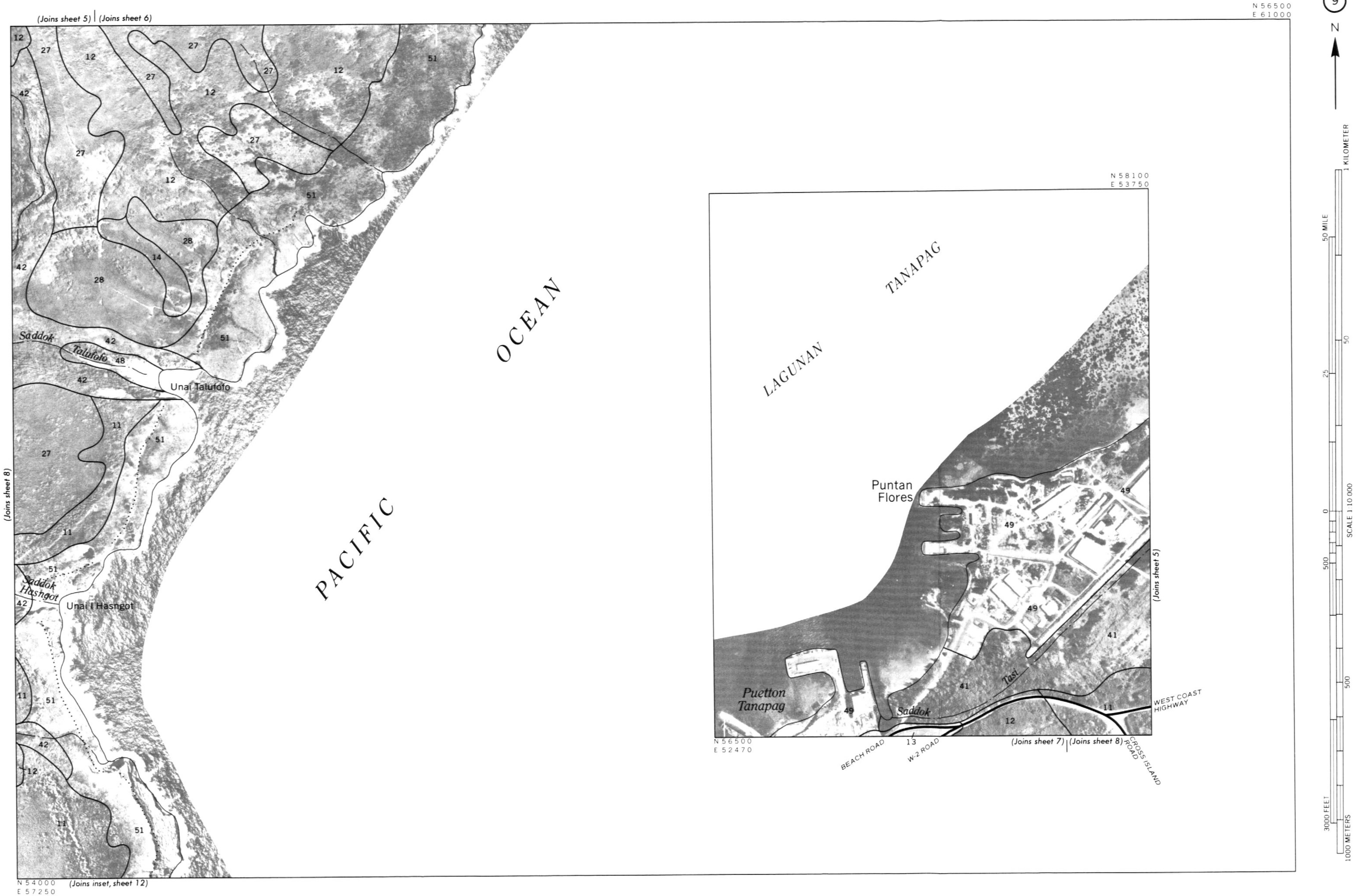


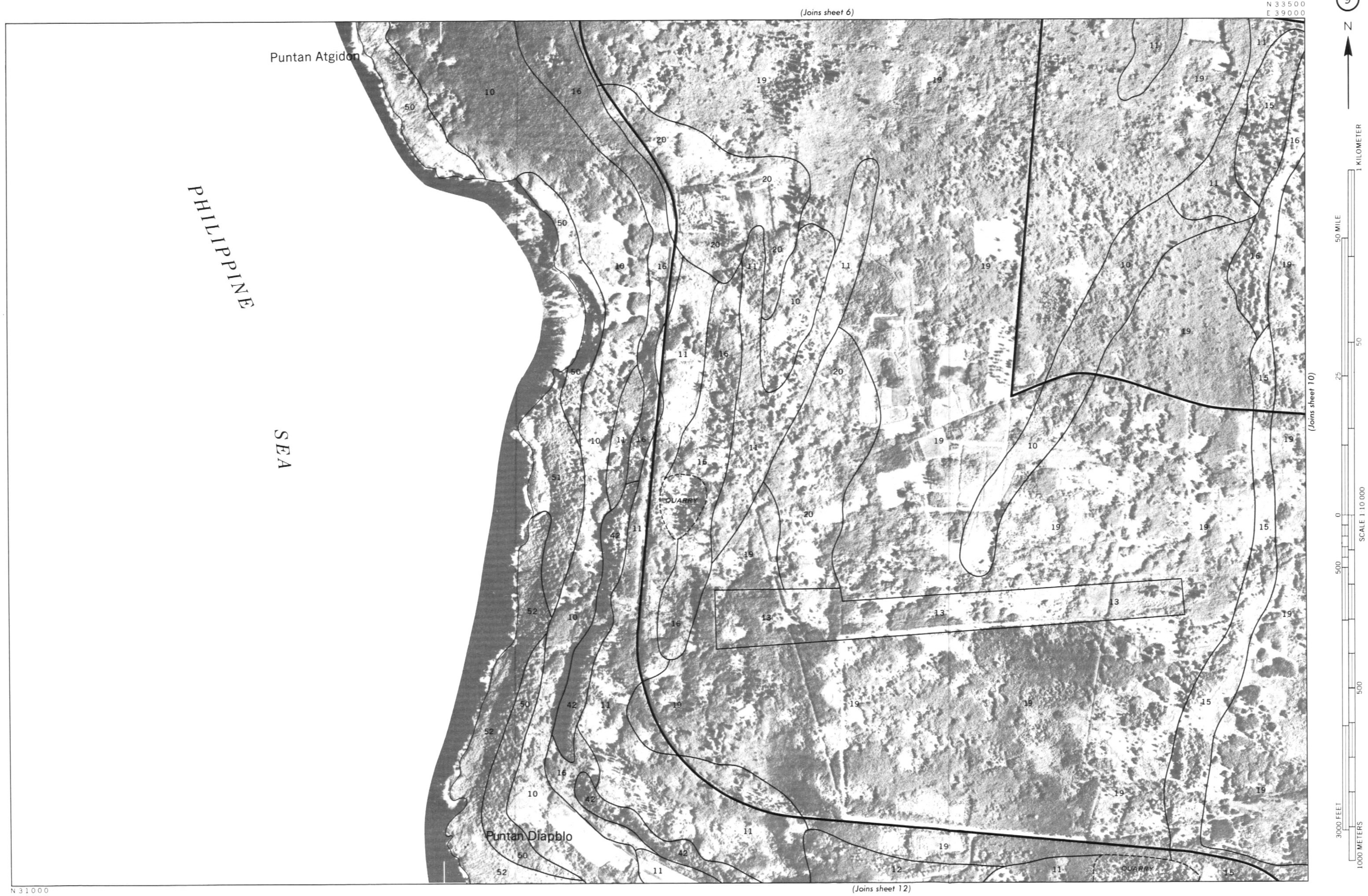
This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

ISLAND OF ROTA, NO. 9



This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography

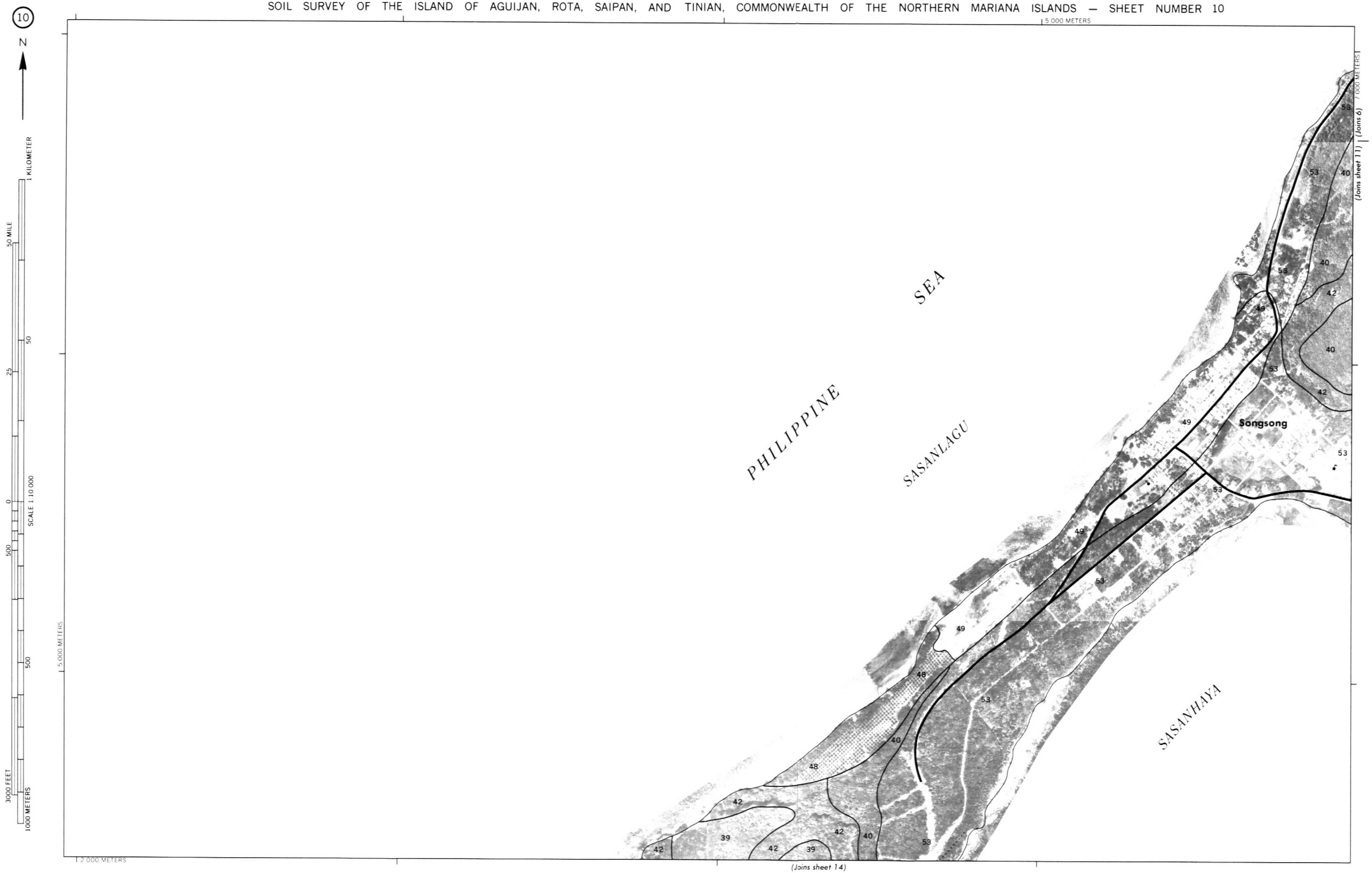
ISLAND OF SAIPAN, NO. 9



This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

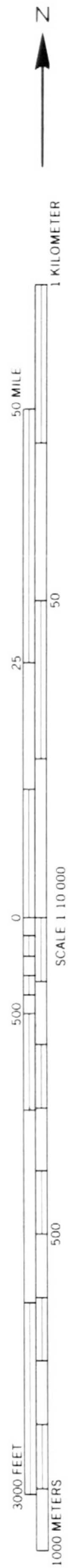
ISLAND OF TINIAN NO. 9

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 10



ISLAND OF ROTA, NO. 10

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.



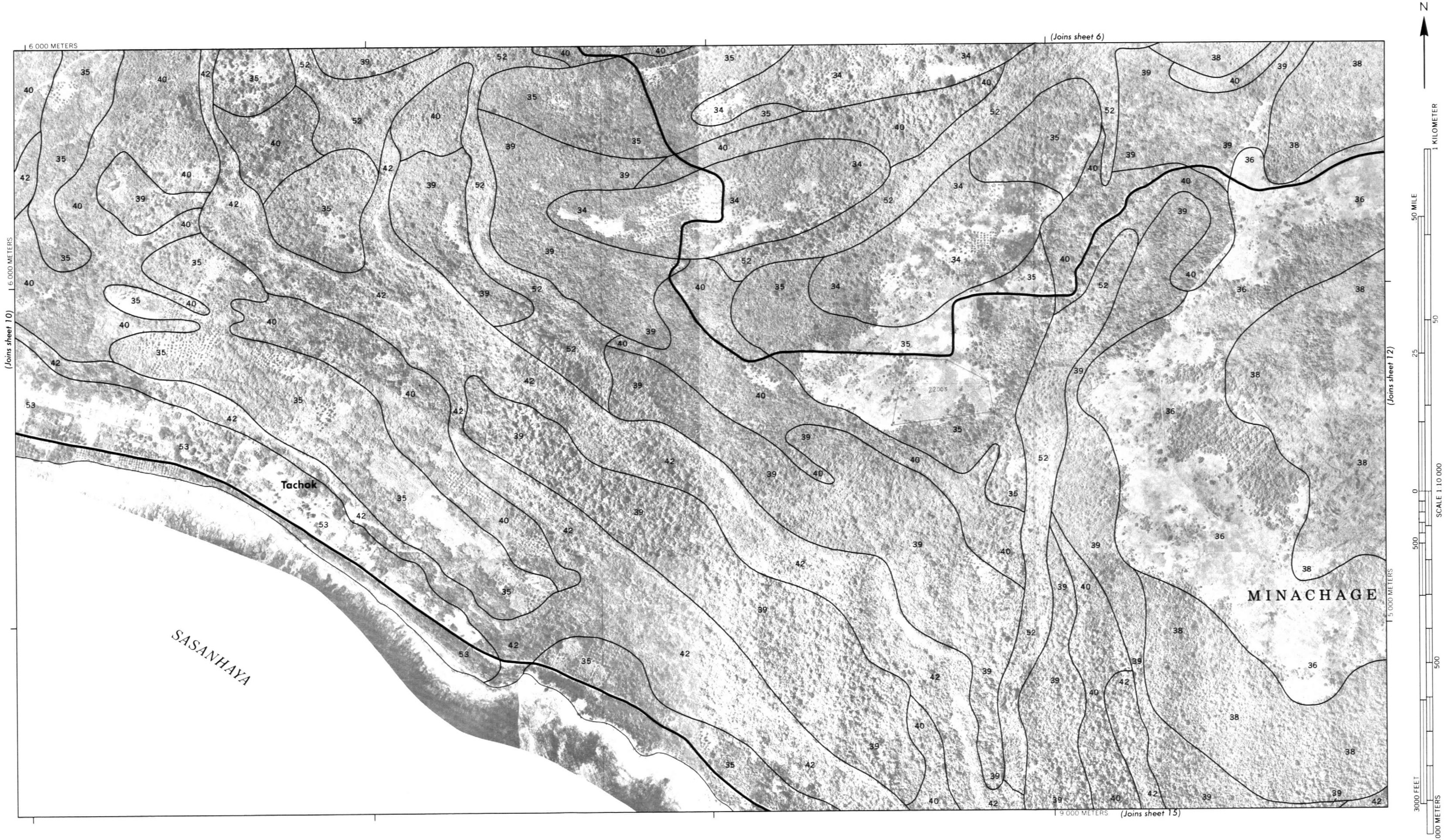
ISLAND OF SAIPAN, NO. 10

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 10

ISLAND OF TINIAN NO. 10

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography



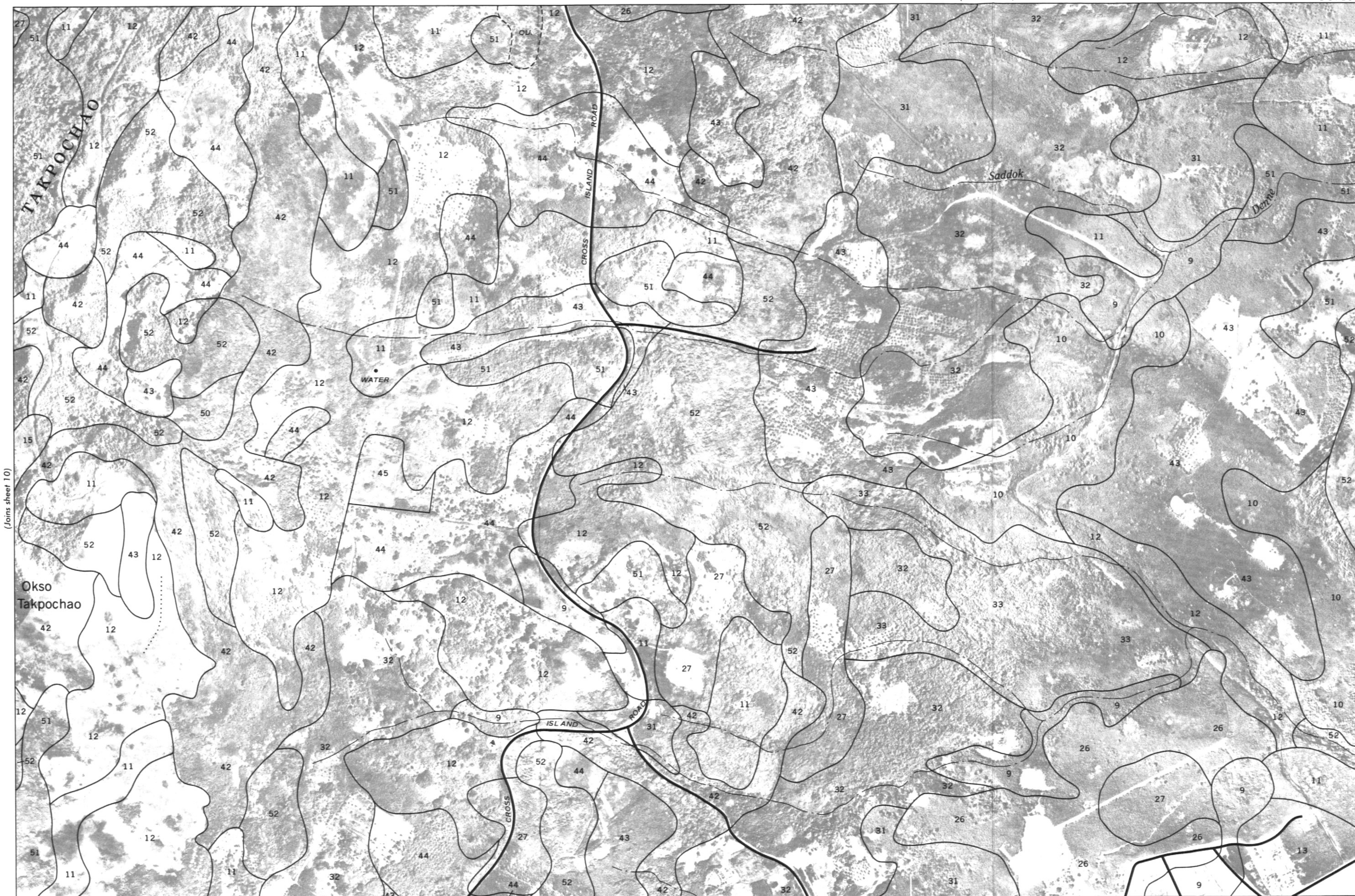
This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

ISLAND OF ROTA, NO. 11

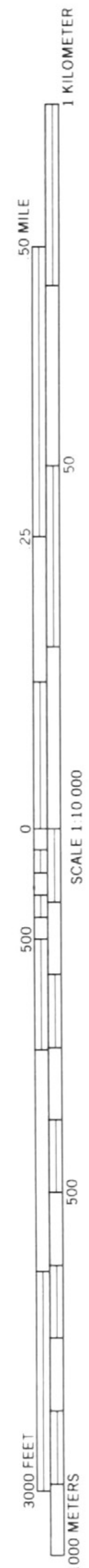
11

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography

ISLAND OF SAIPAN, NO. 11



N



11

(Joins sheet 8)

N 33500
E 46500

(Joins sheet 10)

N 31000
E 42750

(Joins sheet 14)

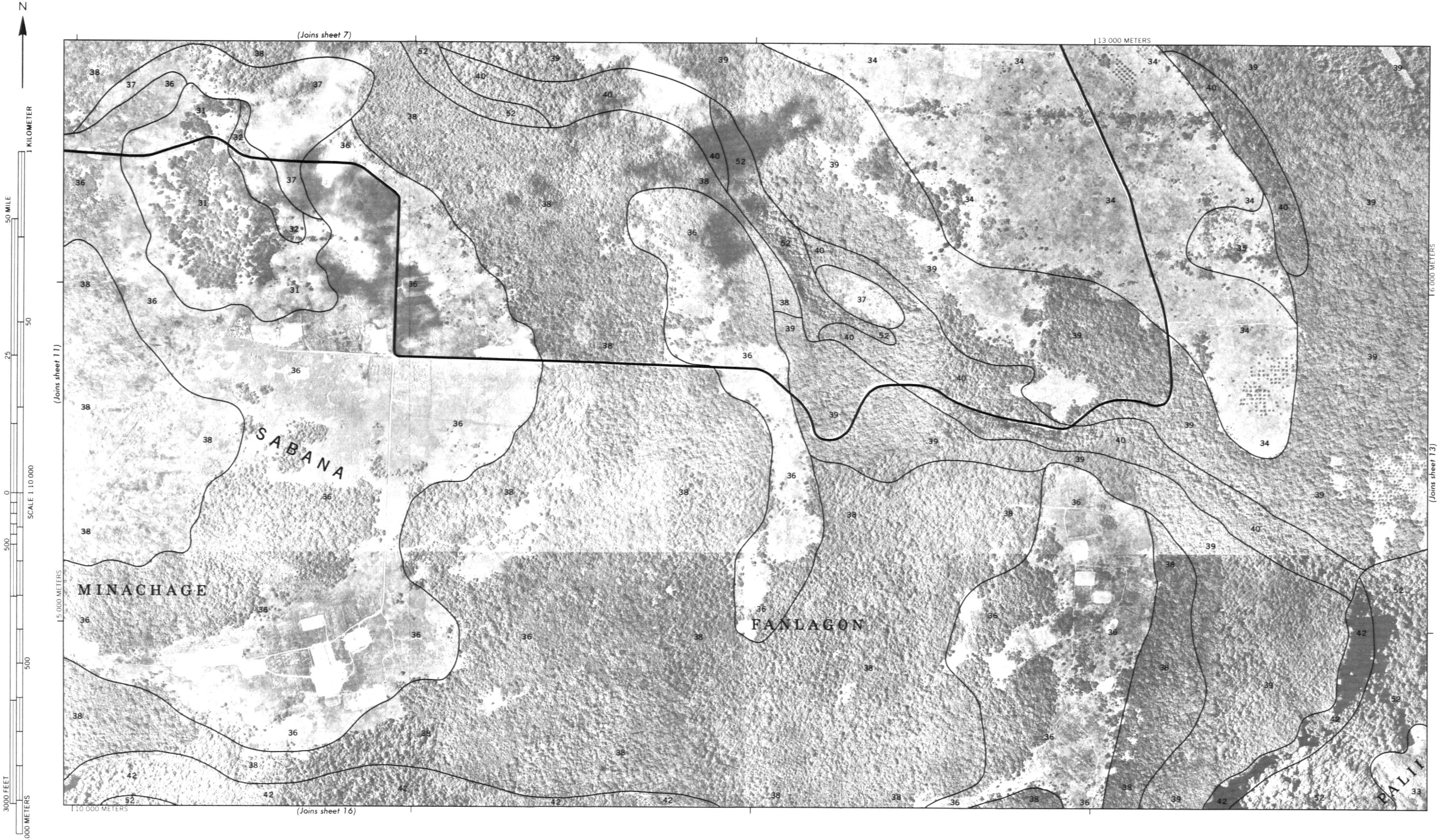
N

1 KILOMETER
50 MILE
SCALE 1:10 000
3000 FEET
1000 METERS

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

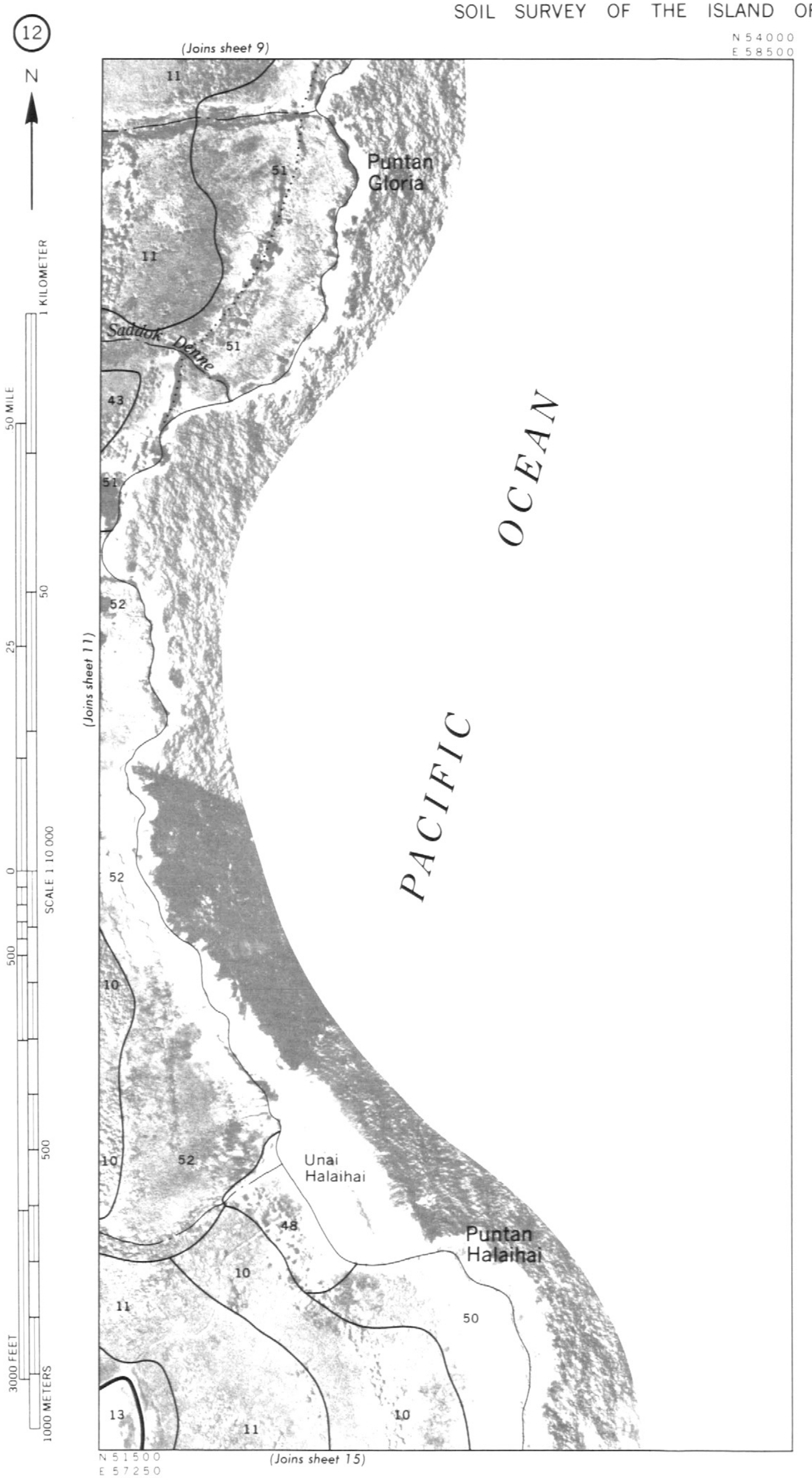
ISLAND OF TINIAN NO. 11

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 12



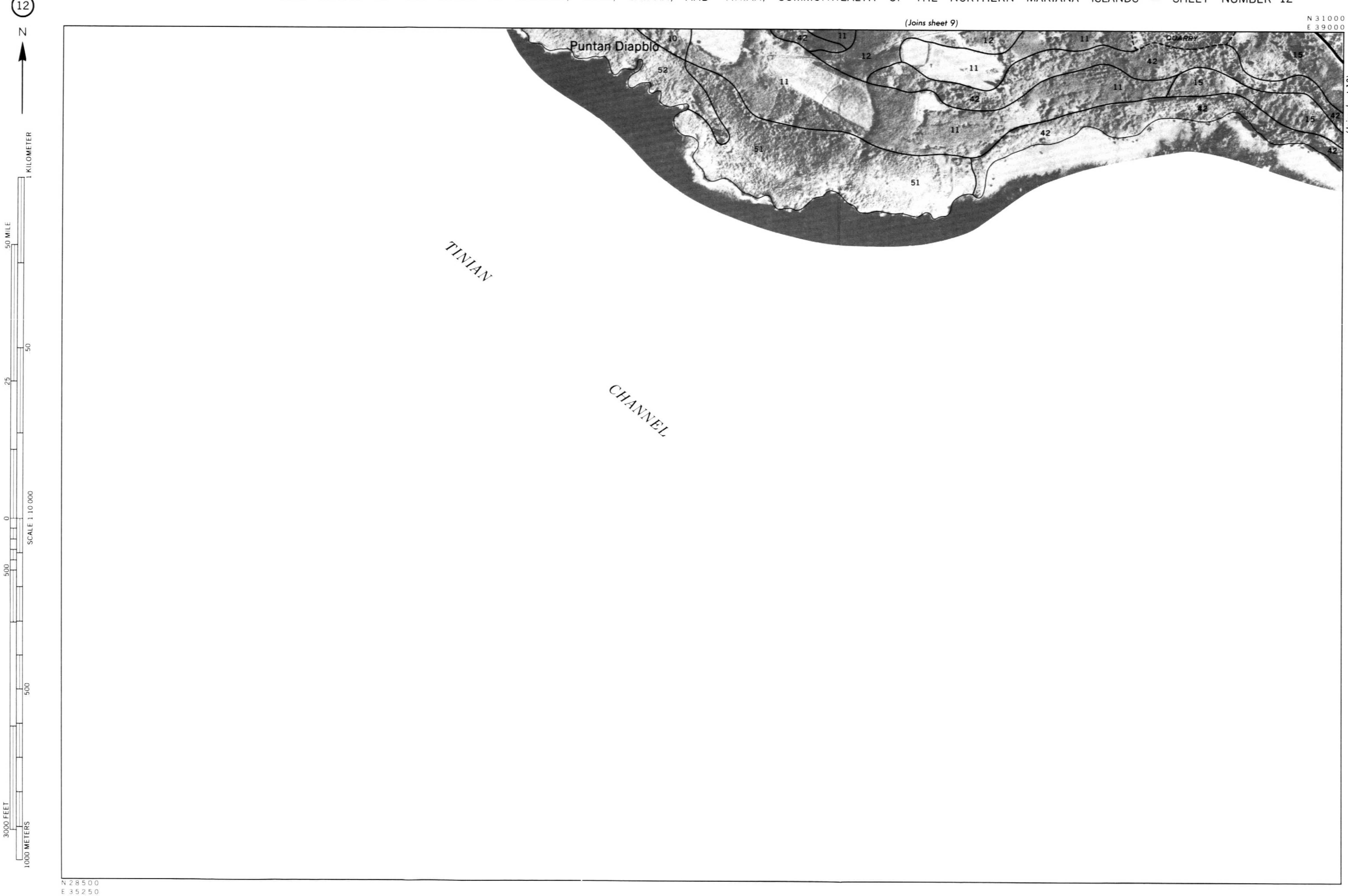
ISLAND OF ROTA, NO. 12

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.



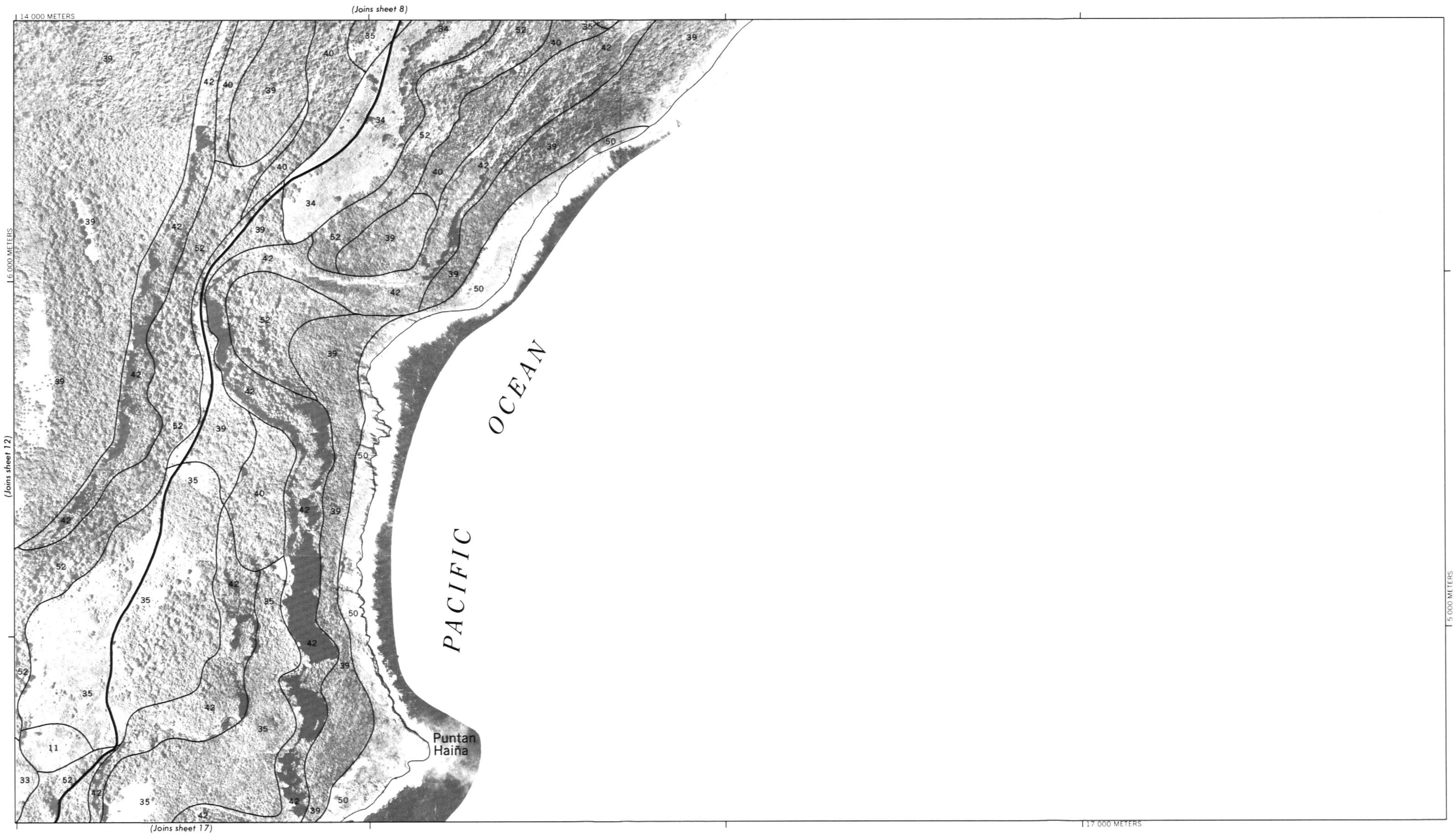
ISLAND OF SAIPAN, NO. 12

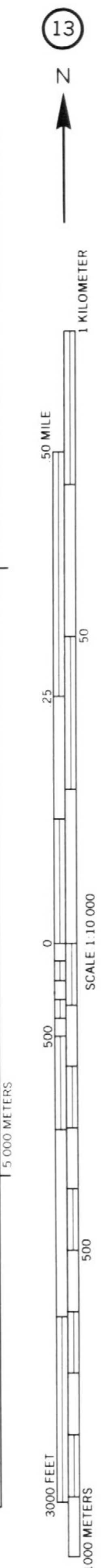
This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.



ISLAND OF TINIAN NO. 12

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.





This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

ISLAND OF ROTA, NO. 13

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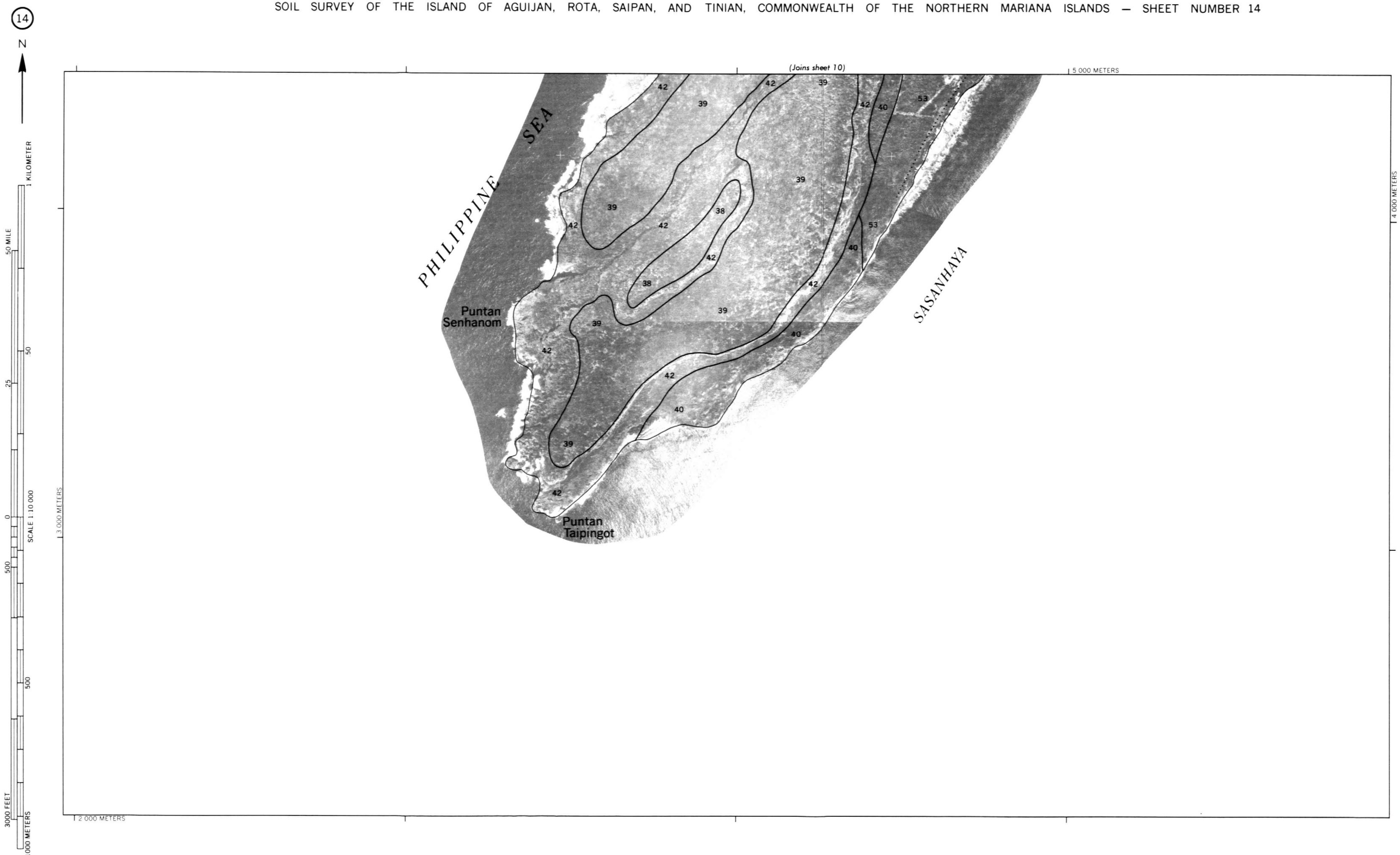
ISLAND OF SAIPAN, NO. 13

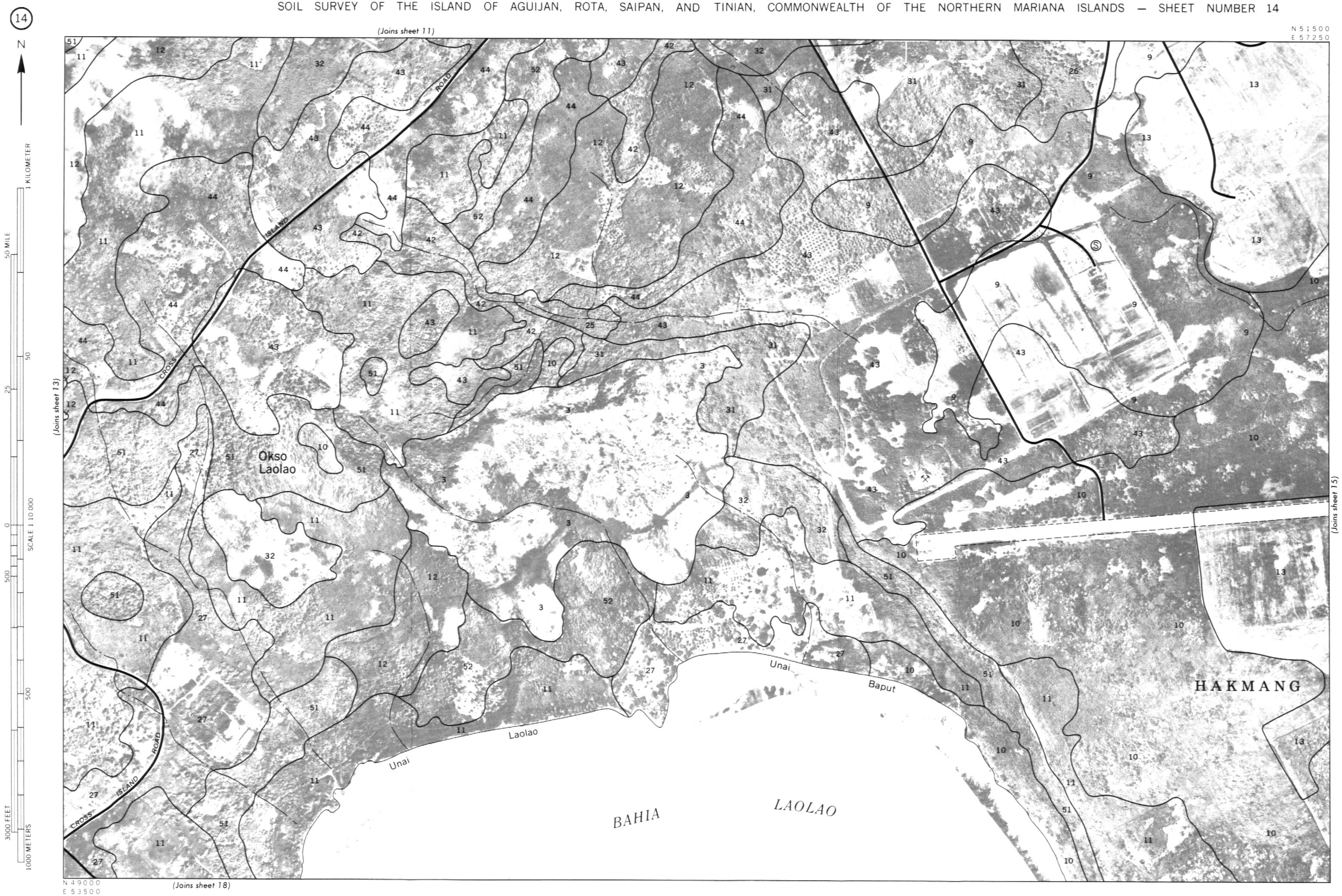
This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography

ISLAND OF TINIAN NO. 13



ISLAND OF ROTA, NO. 14

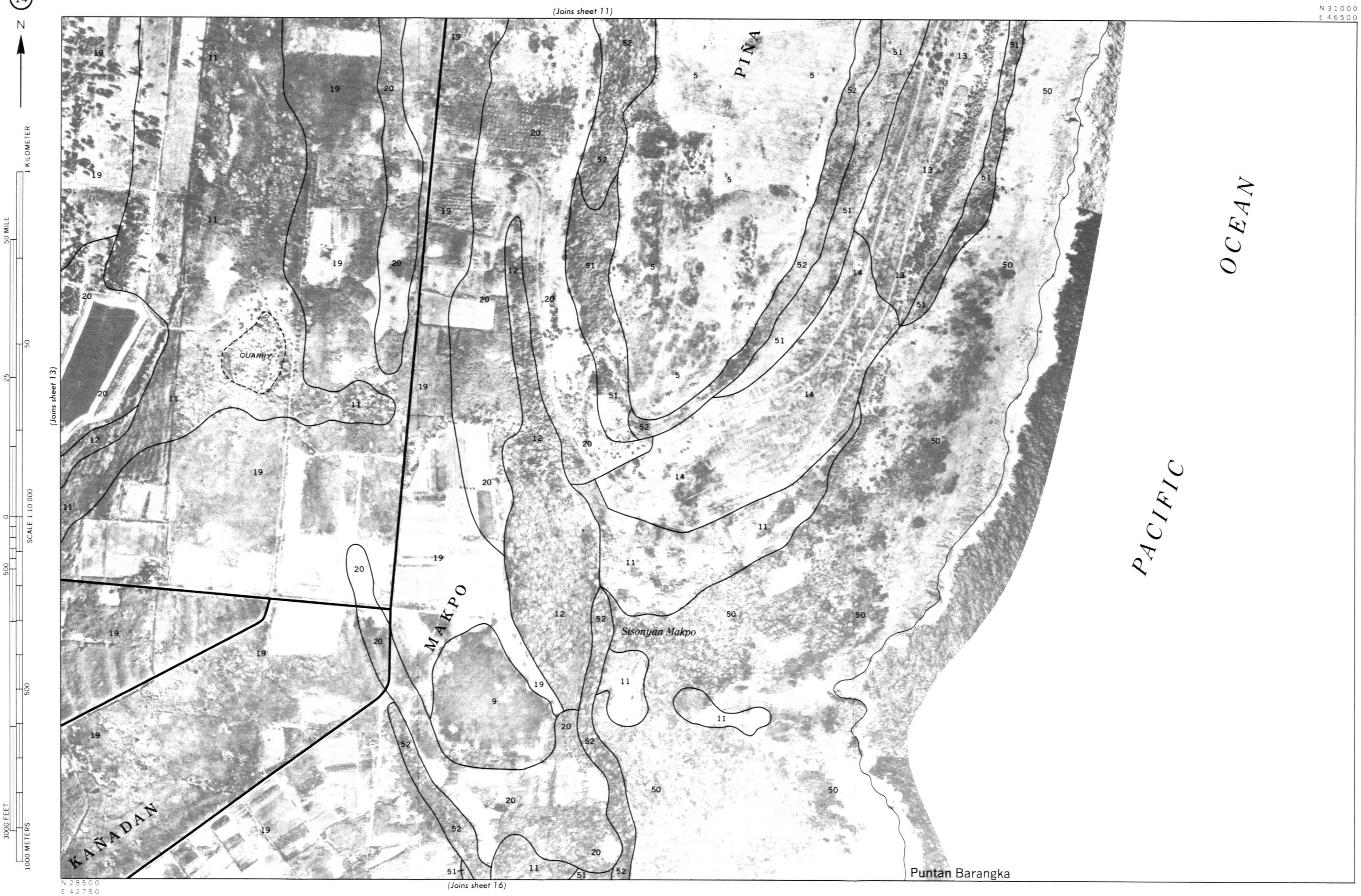
This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.



ISLAND OF SAIPAN, NO. 14

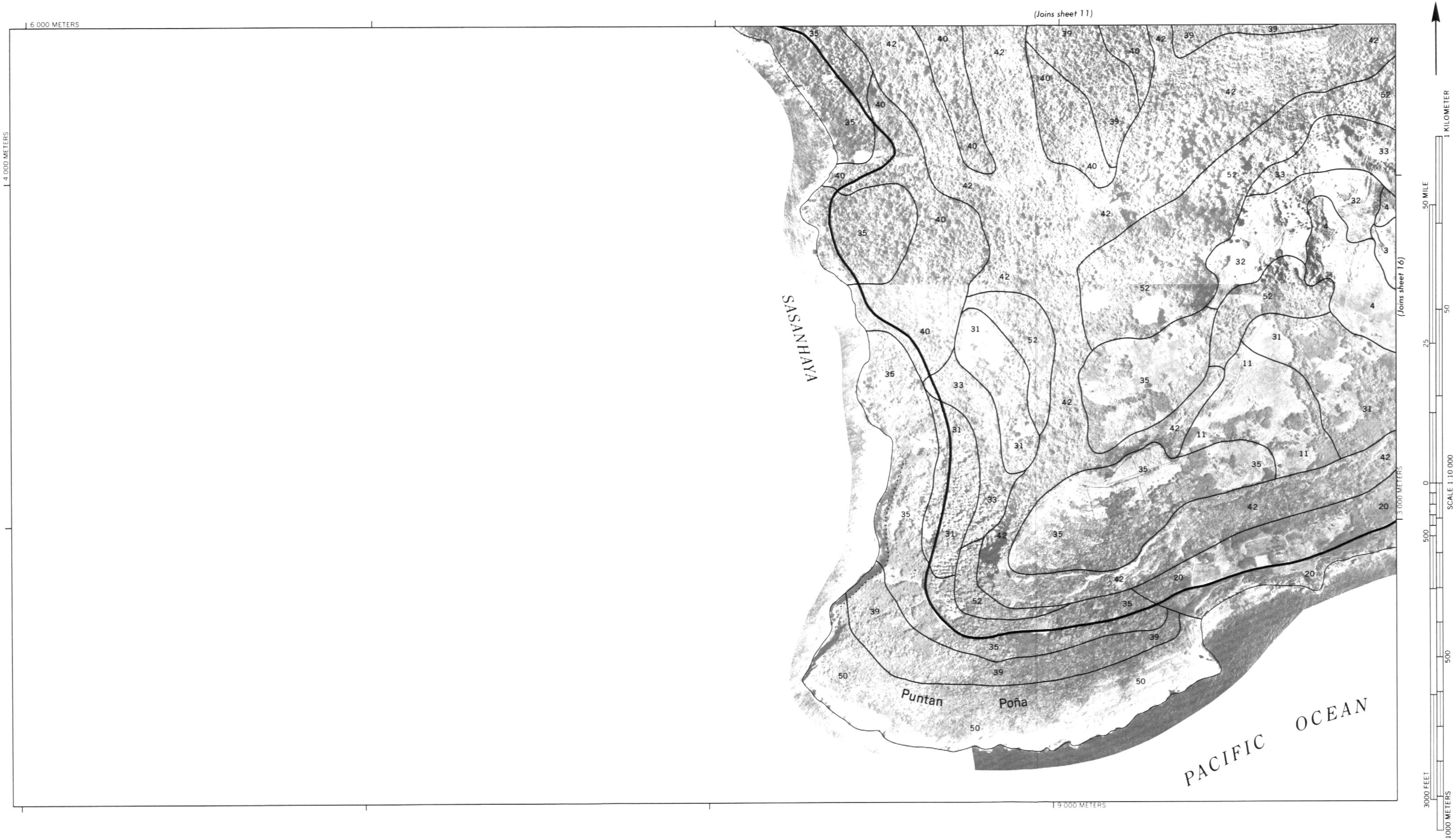
This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 14



ISLAND OF TINIAN NO. 14

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.



This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

ISLAND OF ROTA, NO. 15

(Joins inset, sheet 12)

(Joins inset, sheet 18)

N

1 KILOMETER

50 MILE

SCALE 1:10 000

3000 FEET

1000 METERS

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

ISLAND OF SAIPAN, NO. 15

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 15

15

(Joins sheet 13)

N 28500
E 42750

(Joins sheet 16)

(Joins sheet 17)

N 26000
E 39000

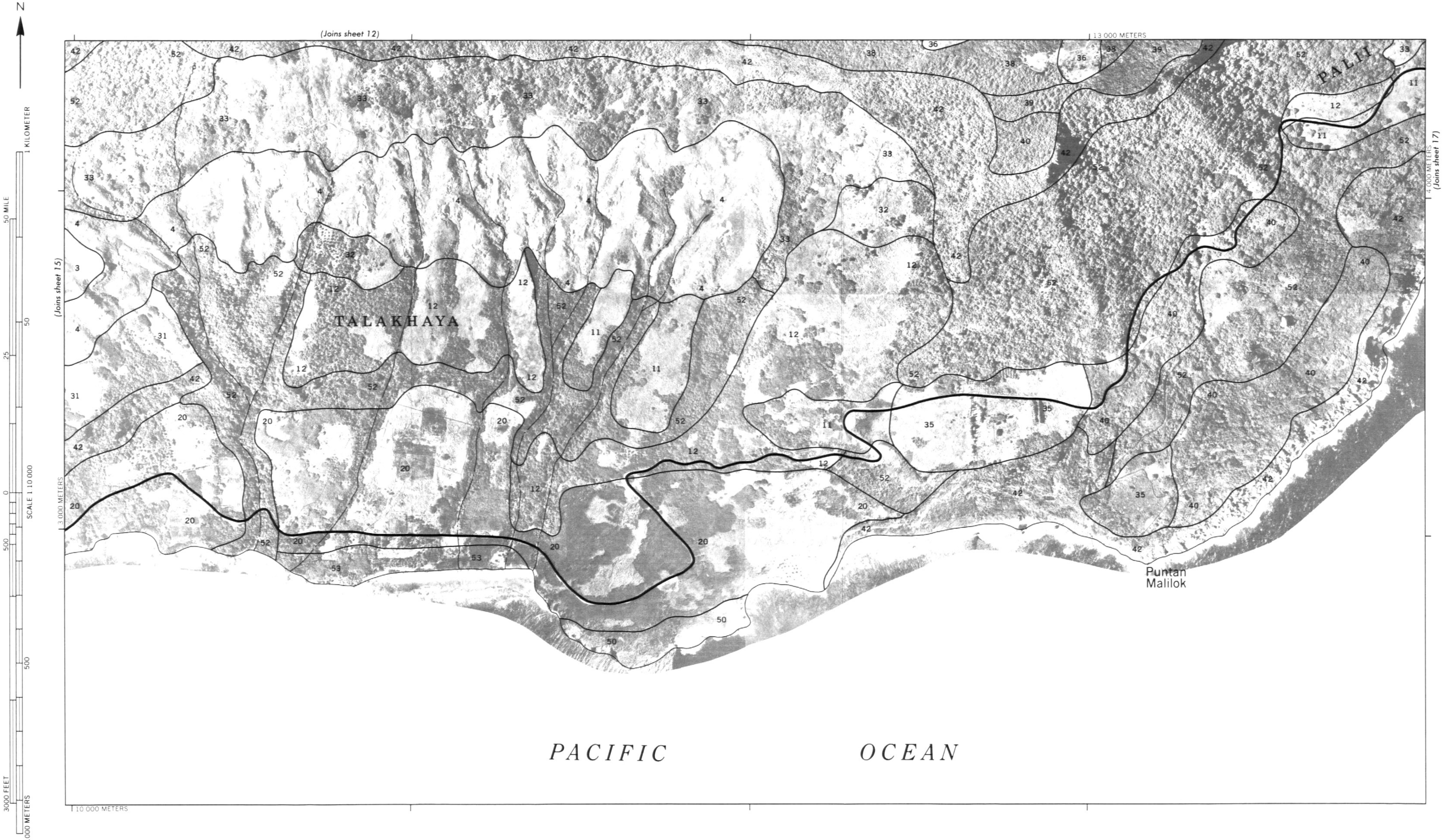
N

1 KILOMETER
50 MILE
0
SCALE 1:10 000
3000 FEET
1000 METERS

ISLAND OF TINIAN NO. 15

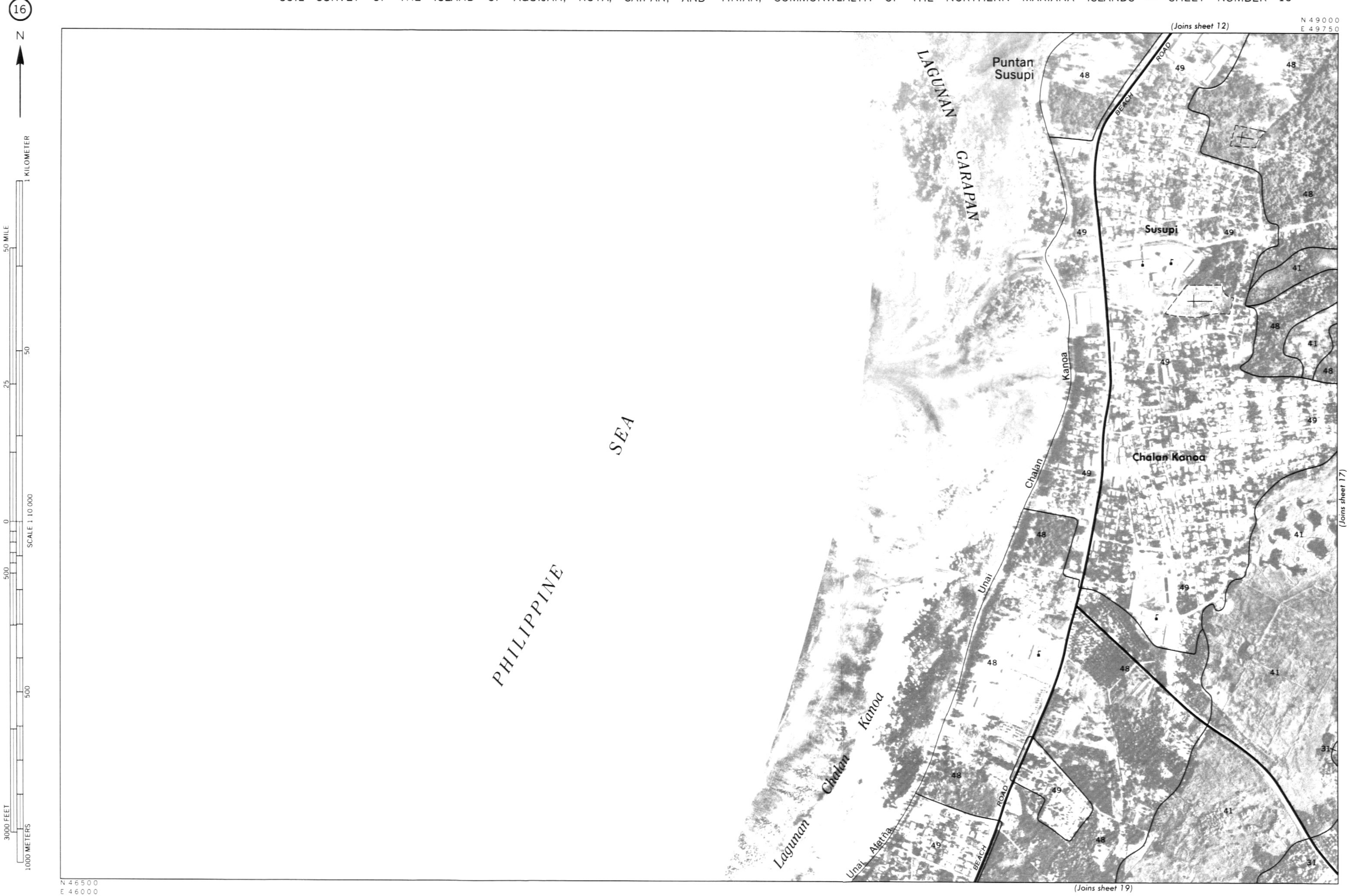
This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 16



ISLAND OF ROTA, NO. 16

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography



ISLAND OF SAIPAN, NO. 16

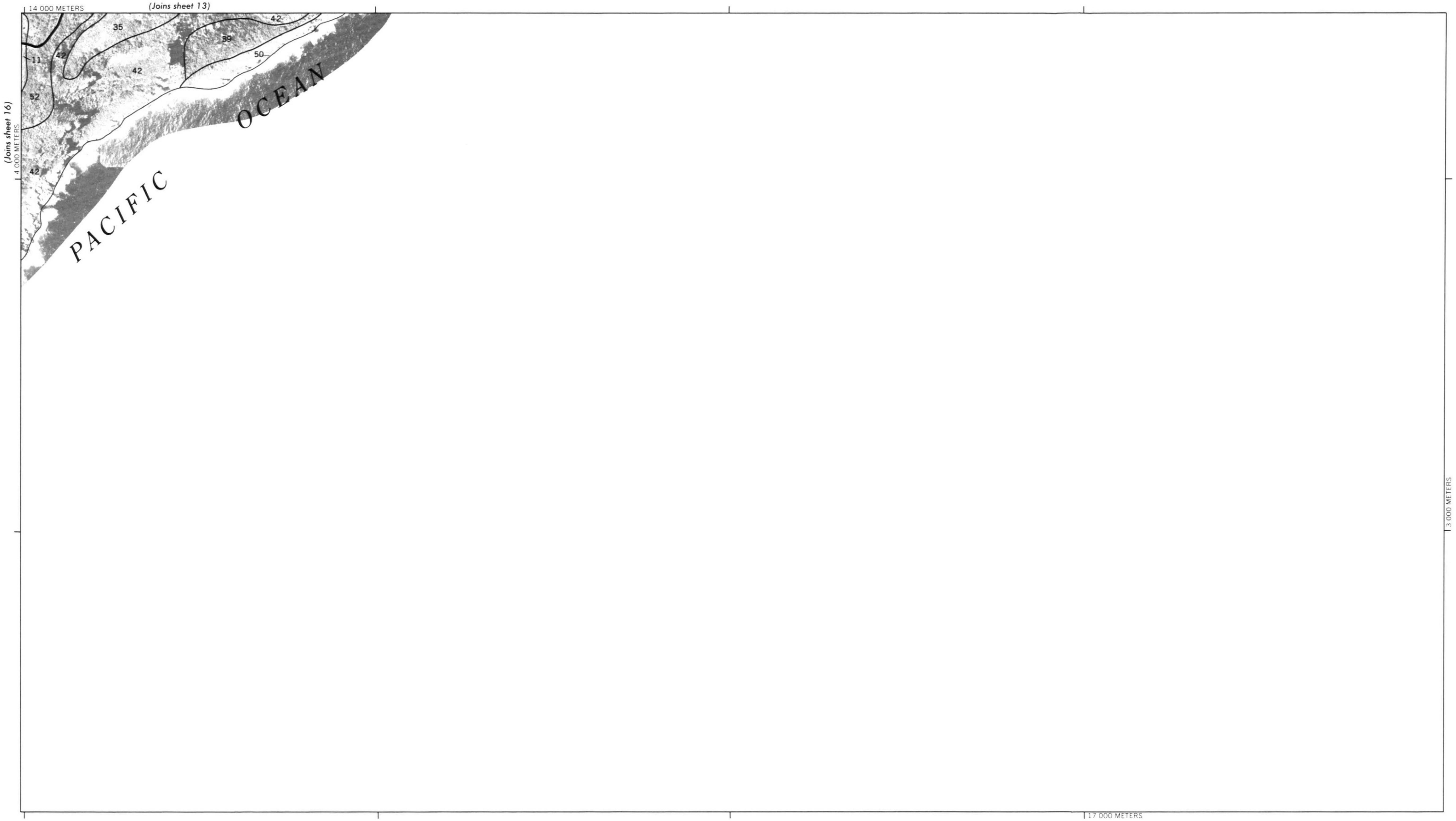
This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

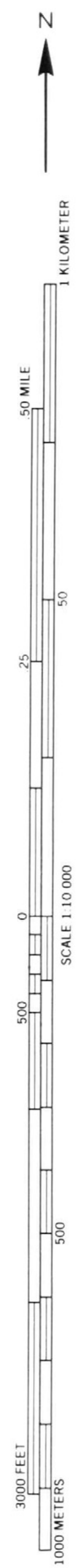
SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 16

ISLAND OF TINIAN NO. 16

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

17





This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

ISLAND OF ROTA, NO. 17

(17)

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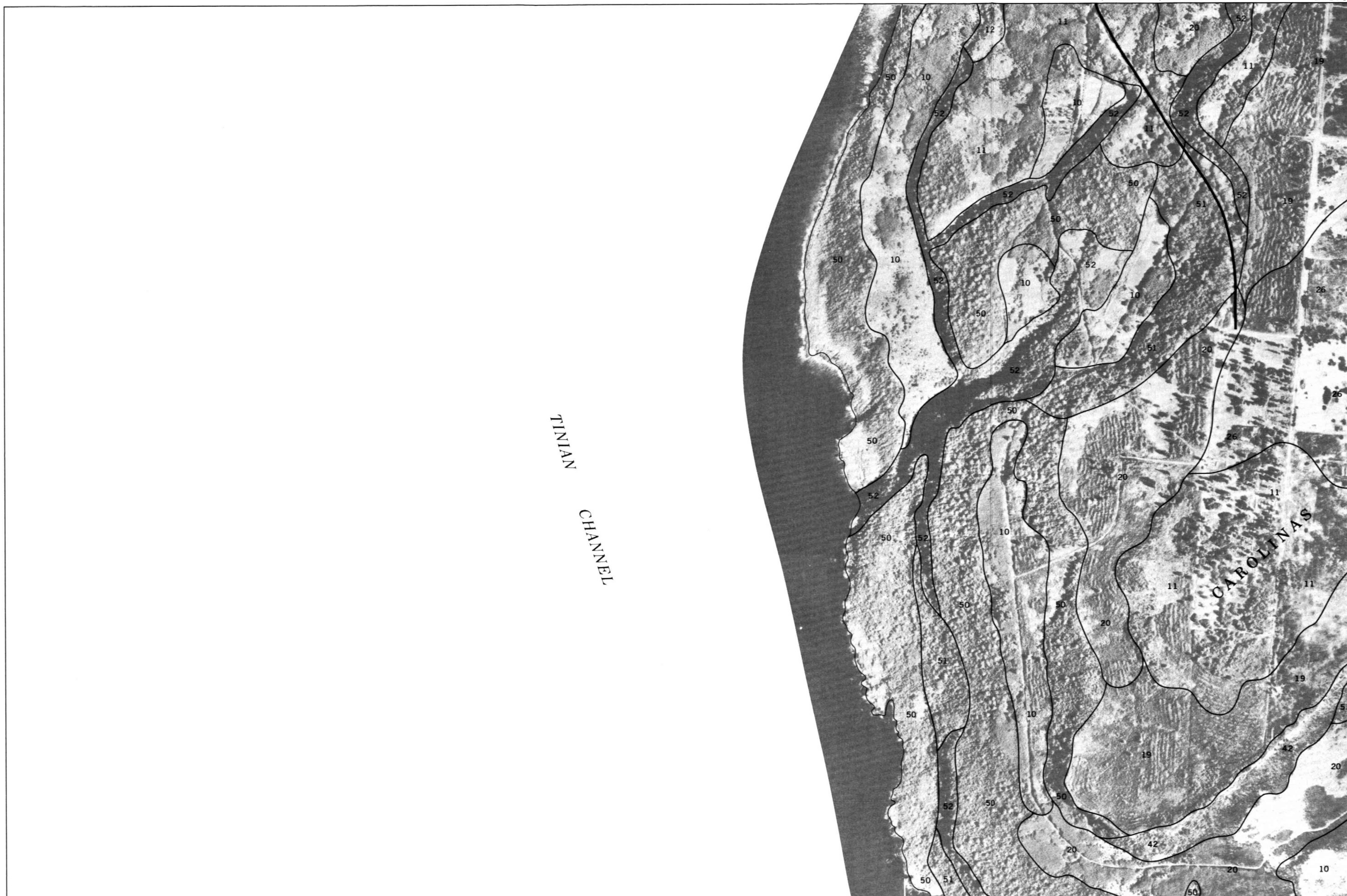
ISLAND OF SAIPAN, NO. 17

17

(Joins sheet 15)

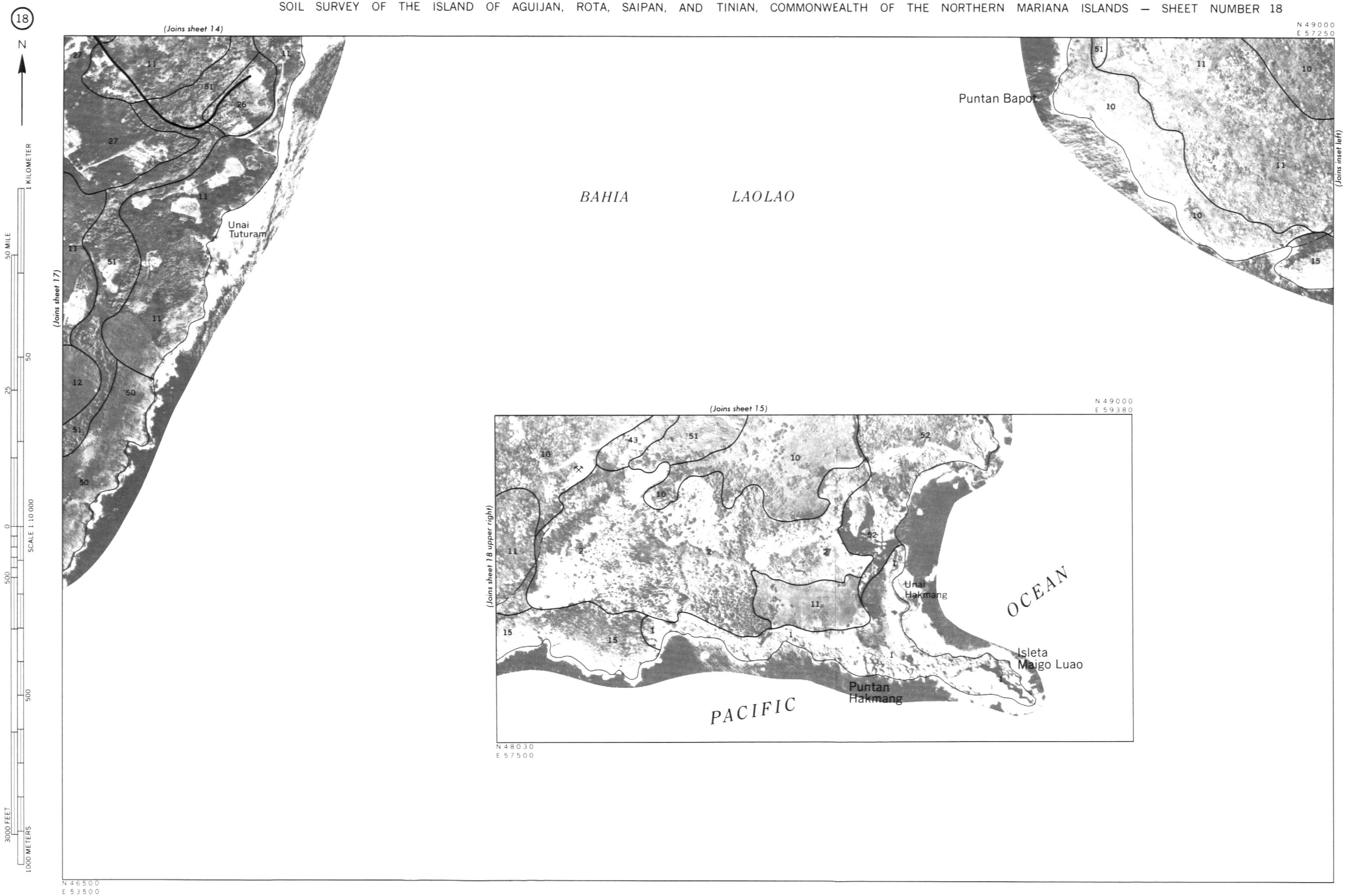


(Joins sheet 19)

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

ISLAND OF TINIAN NO. 17

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 18



ISLAND OF SAIPAN, NO. 18

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ISLAND OF TINIAN NO. 18

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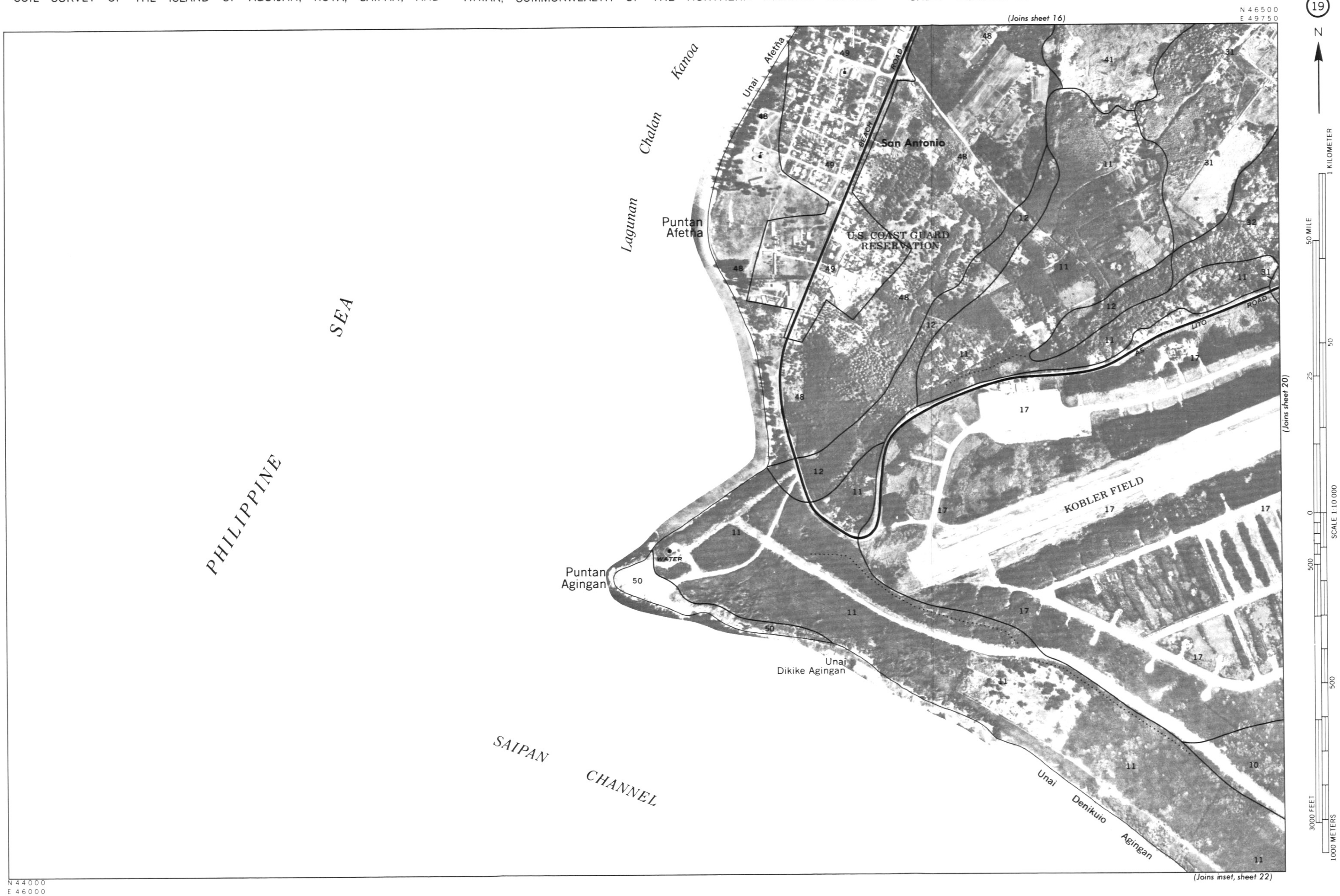
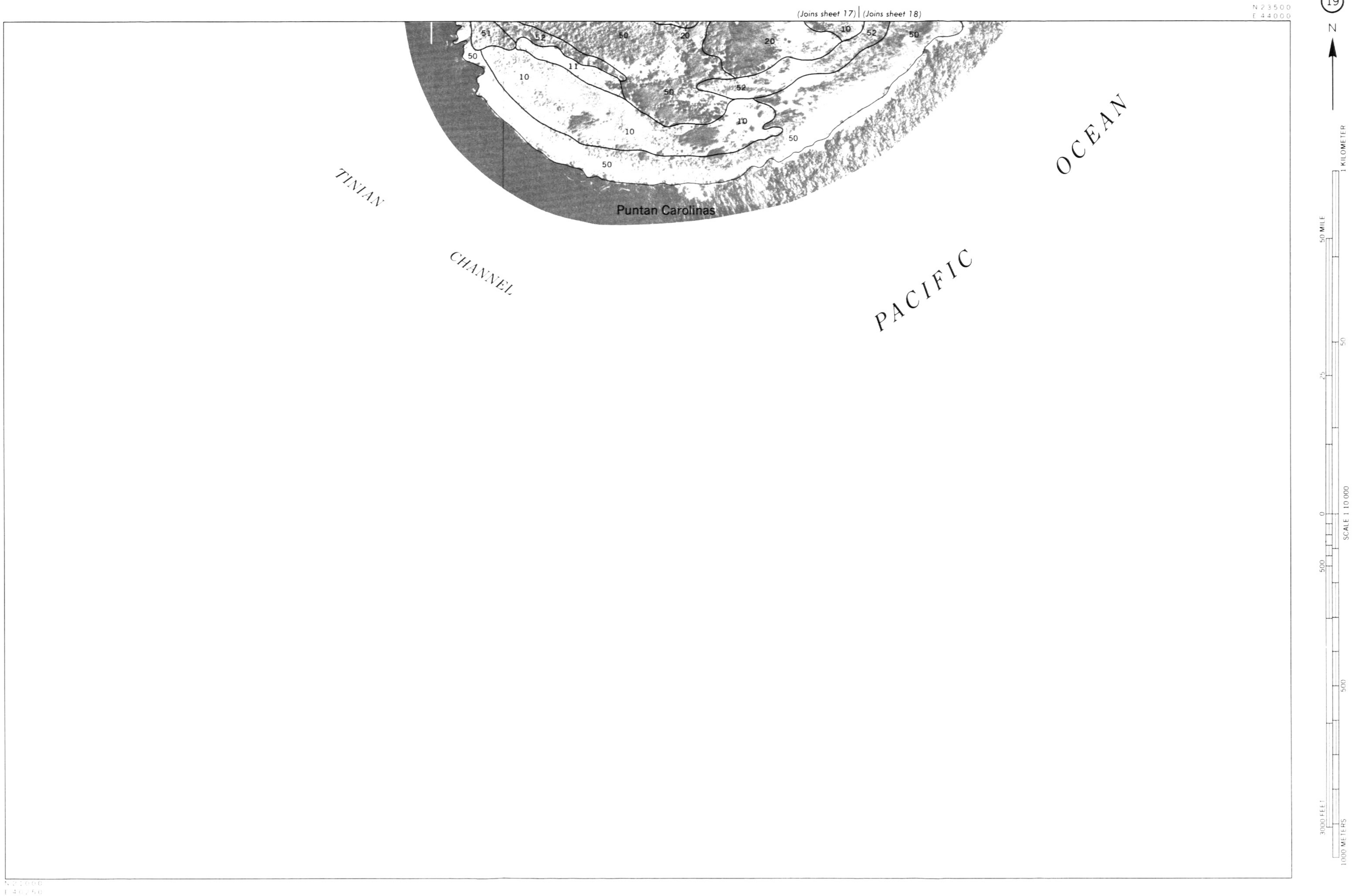
SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 19



ISLAND OF SAIPAN, NO. 19

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

(Joins sheet 17) | (Joins sheet 18)



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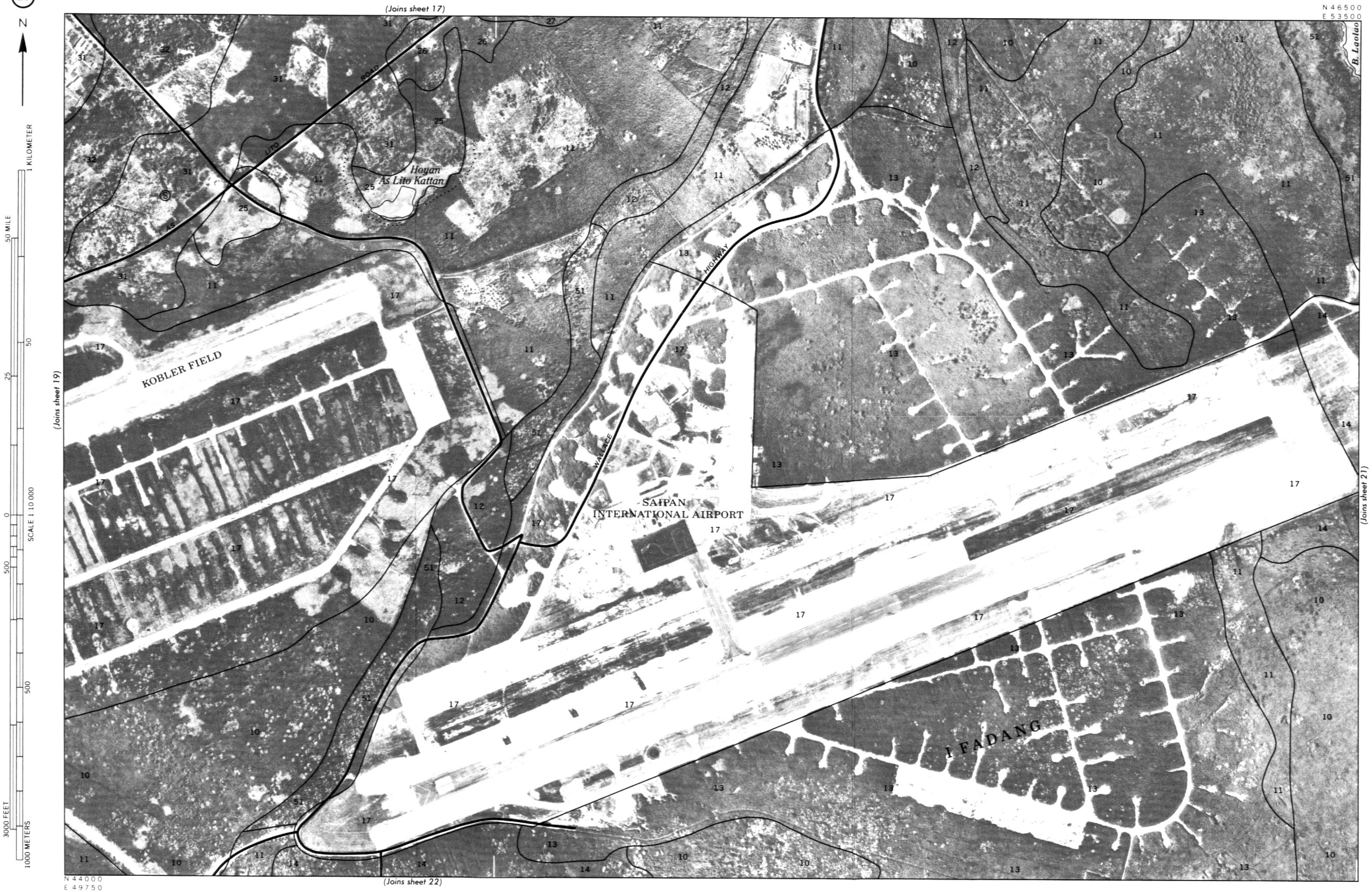
ISLAND OF TINIAN NO. 19

20

SOIL SURVEY OF THE ISLAND OF AGUIJAN, ROTA, SAIPAN, AND TINIAN, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS — SHEET NUMBER 20



ISLAND OF SAIPAN, NO. 20

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

N 46500
E 57250

(Joins sheet 20)

N 44000

(Joins sheet 23)

N

1 KILOMETER
1/2 MILE
SCALE 1:10 000
3000 FEET
1000 METERS

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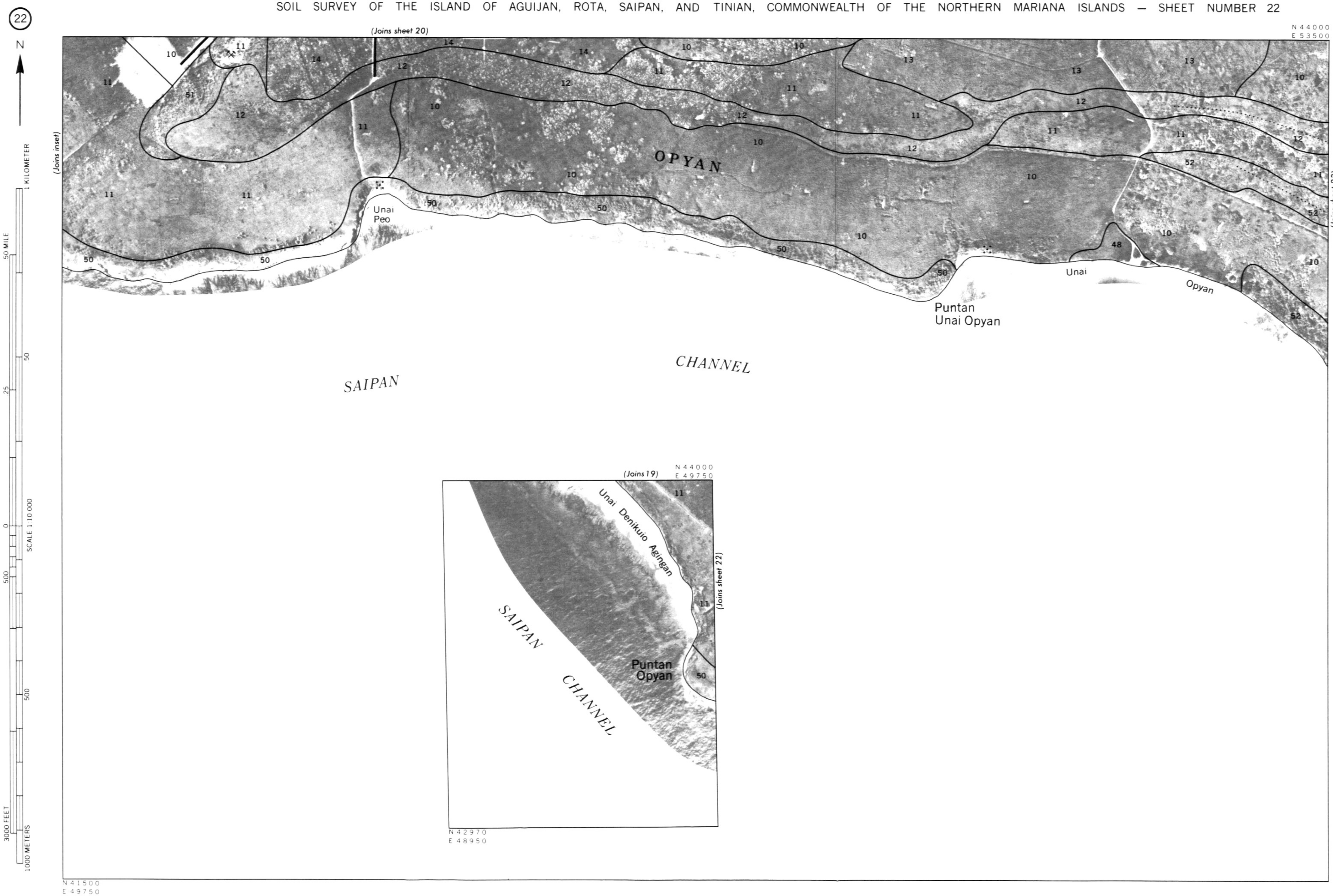
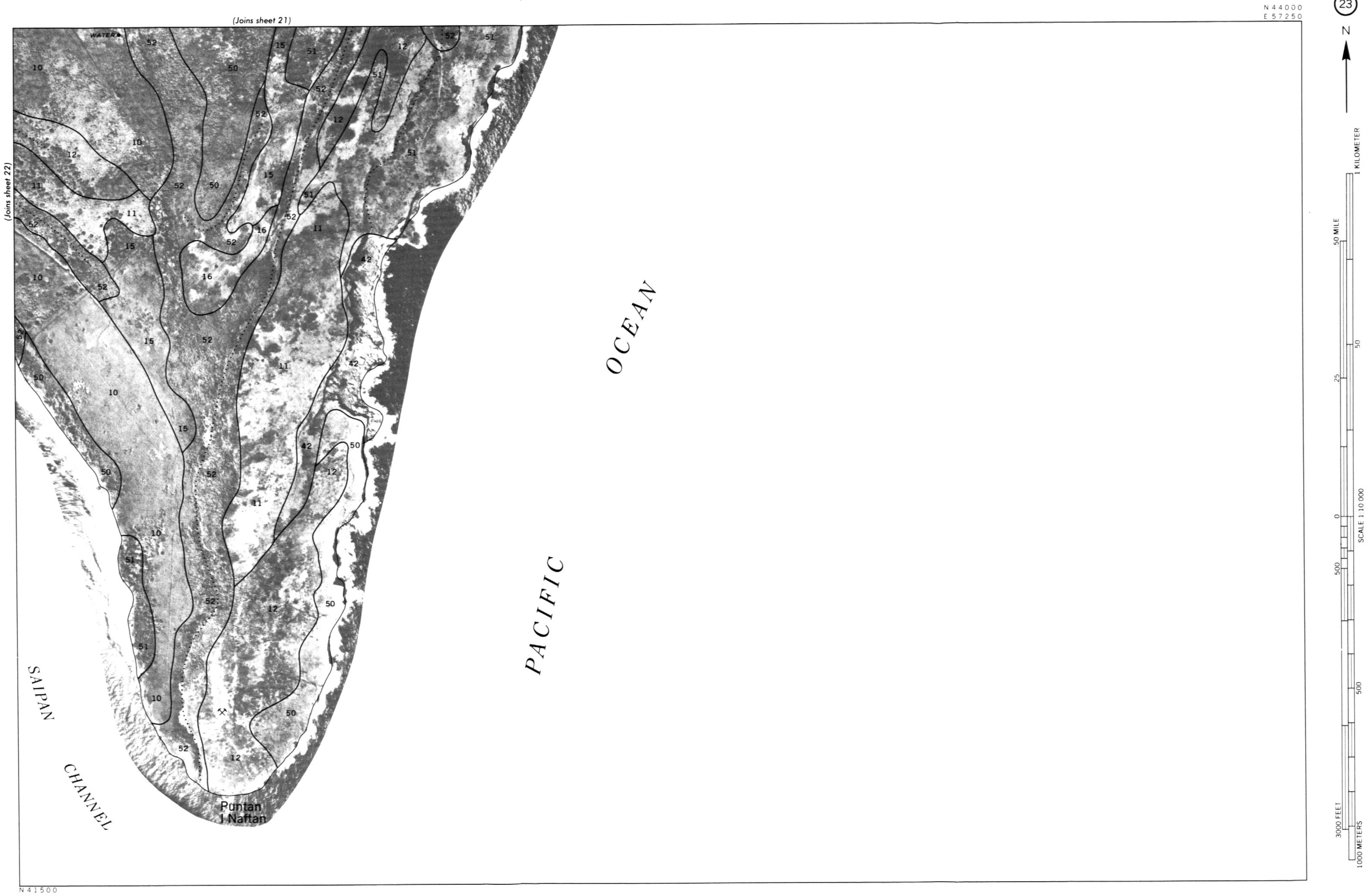
ISLAND OF SAIPAN, NO. 21



ISLAND OF SAIPAN, NO. 22

This soil survey was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and the Department of Natural Resources, Commonwealth of the Northern Mariana Islands. Base maps are prepared from 1976 orthophotography.

23



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ISLAND OF SAIPAN, NO. 23